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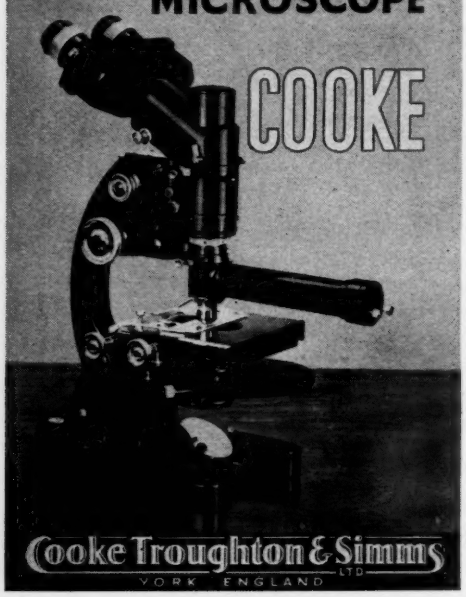

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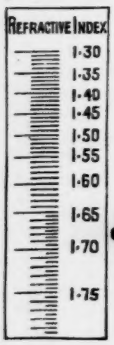

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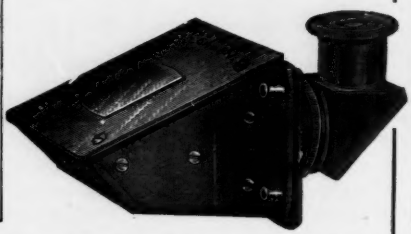

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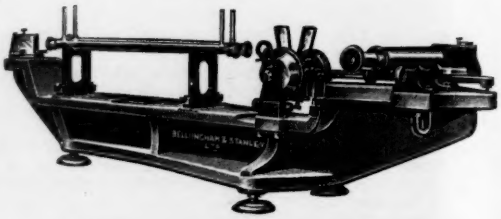

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TECHNOLOGICAL HUMANISM

THE 1955 conference of the Scottish Institute of Adult Education, which was held at Dunblane, provided Sir Eric Ashby with another opportunity to continue his inquiry into the malaise which seems to afflict adult education in Great Britain (*Scottish Adult Education*, No. 15 ; December 1955). It can be read with profit during the discussion of the White Paper on Technical Education in Britain just issued (see p. 461).

Adult education, he suggested, is in a dilemma of ends and means. There is, of course, a vague end in view. Although education for leisure and for personal satisfaction is now declared to be the purpose of adult education, it is a very shadowy purpose compared with that of (say) a Workers Educational Association class of forty years ago. That class was an instrument to secure social and political emancipation. Its purpose was vocational in the highest sense of the word : it was for men who believed they had a vocation. The ends were clear, but the means were on the whole inadequate for the ends. Now the means have become more adequate, but the ends have become clouded.

It is misleading to make an issue of differences between technical and cultural education. Some of our perplexities in universities, technical colleges, and further education have their origin in the antithesis which has been set up between these two groups of ideas and the consequent controversies over what should be the balance between them. A distinction between vocational and non-vocational education can be made ; it is questionable whether it is worth making.

To-day a gifted man cannot play his part in society unless he is something of a specialist. Instead of fighting a rearguard action on behalf of general education against specialization, is it not more important to consider whether the benefits of humanism cannot be acquired through, and not in spite of, specialization ?

Sir Eric went on to discuss whether a new concept of liberal education is desirable ; and, what the new concept and interpretation should be.

One must start with the sound academic maxim that no change is desirable for its own sake ; that change is justified only if there is pressure due to other uncontrollable changes which have already occurred, or in anticipation of such uncontrollable changes. In Britain personal education enjoys the greatest prestige, despite all that is being done in the way of technical education and education for economic ends. Personal education is the keynote of grammar schools, it is the traditional function of the arts faculties of universities, and it is by Government regulation defined as that part of further education called liberal adult education.

Is this emphasis on personal education consistent with the present state of Western society ? The world has changed out of all recognition, and accompanying these changes there are new anxieties.

These changes have two consequences. There is a new preoccupation with resources ; people worry about food, about new forms of energy, about new materials ; and there is a phrenetic concern for security—secure jobs, secure status in the community, national security. Society is again living dangerously and spends most of its time thinking about means and not ends.

Do these great social changes justify a change in the concept of liberal education, a re-examination of humanism ? No one would assert that the old literae humaniores are reaching the bloodstream of modern civilization. That is the problem which frustrates educators ; not that the old humanism has become outmoded but that it has become impotent.

We are entering a civilization of experts and technicians. The humanism appropriate to such a civilization must be one that confers values on the automatic factory, the aeroplane, television, and the popular Press ; it must have something to offer the sort of man who a century ago could neither read nor write, and who now reads only the popular Press and listens to the Light Programme of the B.B.C. For these reasons there should be a re-interpretation of humanism, and the purpose of liberal education should be to transmit this re-interpretation, which must, of course, embody the imperishable elements of earlier humanisms. Sir Eric declared his belief that the missionaries of the new humanism would not be in schools but in adult education.

As a basis for humanism, science has one insurmountable disqualification. It is of the essence of the scientific method that the human element must be eliminated. Science does not dispense with values but it does eliminate the variety of human response to values. It is concerned only with phenomena upon which all qualified observers agree. Its whole energy is devoted to describing, measuring and classifying natural phenomena in such a way as to secure agreement among all men ; and this can be done only by making its values independent of man. The whole procedure of the scientist assumes that science has to be dehumanized.

Scientific humanism should therefore be ruled out as an alternative to classical humanism. There is another alternative which could be called technological humanism. The unique characteristic of our ago is not the scientific way of thinking but the bewildering way in which the applications of science to society have shaken the foundations on which society has stood for centuries, and have raised not simply economic issues but also moral and ethical issues. Chemotherapy and preventive medicine, for example, have enormously altered the pattern of family life. The applications of science to industry have already created a problem of the mass production of leisure. The aeroplane and the radio have devalued the classical methods of diplomacy.

Is it not essential that liberal education should include an understanding of the social and moral

consequences of technology and should concentrate upon the re-interpretation of the old values in such a way as to make them relevant to the new civilization which is upon us ?

This is not the only justification for the study of technology as part of a liberal education. The greater justification is that in the broad study of technology there are many of the ingredients which have for centuries been associated with a liberal education. Technological humanism could preserve the best of the traditional humanism: it could be catholic and continuous with the past; and at the same time it could enter the bloodstream of modern society, which the old humanism fails to do.

Technology concerns itself with the creative acts of man. To enthuse about Gothic churches and Tudor town halls and not even to glance at Viscount aeroplanes and stressed concrete bridges cannot be justified on the grounds that only the former are creative arts of man. It is simply an unwillingness to face the present.

Technology has its own standards of excellence and taste. A lot is talked about the shoddiness of mass-produced articles; fibre suit-cases compared with hand-made leather ones, gimcrack furniture compared with Chippendale. This is a weakness inherent in the public who accept these articles and not in technology. Where standards are insisted upon (as in aeroplanes, cameras, or gold watches) there is excellence. The lesson that good design is not necessarily expensive has not yet been learned. The establishment of standards for taste is an essential ingredient of technology.

Technology involves the handling of ideas and the establishing of values. In brewing, for example, there are many abstract ideas which are encountered by a man who wants to master its technology. There are the purely scientific ideas of microbiology, and there is the craft of the structural engineer who designs brewing plant. The beer has to be marketed; mass psychology, the education of public taste, diplomacy, or power politics in dealing with other brewers—all these are needed. This compels the brewer to become interested in tied public houses and hence in the architecture of public houses. If he has a mind receptive of liberal ideas he will be troubled by at least two moral problems. On one hand, he may feel under a moral obligation to put into his tied houses interesting pictures or good music. On the other hand, he could not reflect long on his job without facing the problem of the dangers of excessive drinking, and his responsibility for it; and to deal with these questions takes him into ethics and even religion.

Technology offers social coherence. One function of a liberal education is to endow people with a common heritage. In the past, technology has not been an instrument of coherence but rather of disruption. Is it not possible that technological humanism could change that ? Could the machine not be made a cement between the manager and the worker, the administrator and the employee ? If both sides shared a common appreciation of machines and their function, they would become part of a common heritage. Technological humanism might achieve this end. If these ideas are pursued along the path of technology as well as along the older paths of literature, a greater number of students will acquire a liberal education, and those who take this particular path are likely to have a great influence on mass communication and propaganda, which will set the cultural standards of the bulk of the people.

EARLY HISTORY OF THE SURVEY OF INDIA

Historical Records of the Survey of India
Volume III, 1815 to 1830. Collected and compiled by Colonel R. H. Phillimore. Pp. xxii+534, and 19 coloured maps. (Dehra Dun, U.P.: Geodetic Branch of the Survey of India, 1954.) Rs. 20 or 31*s*.

THIS is the third of Colonel R. H. Phillimore's projected five volumes of "Historical Records of the Survey of India", covering the period before 1861 when annual reports were first published. The present volume takes the story from 1815 to 1830, when Everest took over both as superintendent of the Great Trigonometrical Survey and as surveyor-general of India. The period is one of great technical interest, and during it the foundations were laid or consolidated of many of the activities on which the future reputation of the Survey of India was to rest.

The arrangement is the same as in previous volumes. An introductory chapter gives a brief outline of the chief events of the period, and this is followed by detailed accounts of topographical and revenue surveys in the various provinces. Chapters are also devoted to astronomical control, the Great Trigonometrical Survey, professional details, and instruments, maps, administration, pay and allowances and personnel. Biographical notes on the principal characters take up more than a hundred pages, and there is a very comprehensive index. The narrative consists largely of extracts from the correspondence of the main characters in the story. Though this does not make for easy reading, it gives the reader an insight into the characters of the writers and the conditions in which they lived, which would otherwise be hard to convey. The advantages of the method thus more than compensate for any extra trouble in reading.

Probably the most important and far-reaching decision of the period was the recognition of the Great Trigonometrical Survey as the only sure foundation for all survey work and the priority given to it by Blacker when surveyor-general. By 1815 Lambton had extended his triangulation from southern India to Hyderabad, but he was now an old and sick man. Fortunately for the future of surveying in India, the youthful Everest joined as his assistant about three years before his death in 1823, thus ensuring continuity of his ideas and methods.

During the period, the plane-table gained ground rapidly as the main instrument for topographical surveying. It is not clear from this volume whether the method of three-point resection was then in use; and it seems possible that some of the prejudice against the plane-table was due to the earlier and unreliable method of orientation by compass, and resection from only two fixed points. Prior to 1828, Indians were only employed on revenue surveys, largely on security grounds. In that year, however,

the first Indians were trained in plane-table surveying. They thus became the forerunners of that large and distinguished company of Indian surveyors whose skilled use of the plane-table was to make possible the cheap and rapid surveys which during the next hundred years covered a large part of central and southern Asia.

Geographically perhaps, one of the most interesting discoveries of the period was the heights of many of the main Himalayan peaks in the Garhwal–Kumaon region. These were so unexpectedly great that they were at first received with incredulity by the scientists of Europe. Other important geographical discoveries followed the opening of the Assam valley in 1824. This enabled the surrounding hills to be explored and opened the way for the first investigations into the identity of the Brahmaputra and Dihang Rivers with the lower reaches of the Tsangpo.

On the mapping side there was the initiation of the "Atlas of India" in 1822. This was designed to cover the whole country with maps on the scale of a quarter of an inch to the mile on a standard layout. After some uncertainty as to who should do the work, the Court of Directors laid down that the compilation and engraving should be done in Britain from material sent from India. Perhaps this decision was inevitable at the time; but few nowadays would deny that maps from original surveys are best compiled by those with first-hand knowledge of the areas concerned. The establishment of lithographic printing in India at about the same time was another great step forward in the popularization of maps. Hitherto they had been copied by hand from the original compilations, so that few maps were available for distribution; but shortly after the introduction of lithographic printing, the publication of maps for sale in quantity was started.

The production of this volume maintains the high standard of previous ones, and the beautifully reproduced maps and sketches leave the reader with a great respect for the artistic abilities of the early surveyors. Thanks are due to the Government of India for the support which has enabled Colonel Phillimore, in spite of all the changes during recent years, to carry on his great work begun on his retirement from the Survey of India more than twenty years ago. The preparation of the remaining two volumes is already well advanced, and it is to be hoped that they will be published in the not too distant future.

G. F. HEANEY

LIVING MAMMALS

Living Mammals of the World

By Ivan T. Sanderson. Pp. 303 (330 illustrations). (London: Hamish Hamilton, Ltd., 1955.) 63*s*.

THE publishers claim that this book "is an authoritative reference work" which will "in the words of a leading zoologist, 'fill a very important place in the literature of the subject and become a classic for many years to come'". This suggests a high standard of accuracy. The illustrations are said to be "extraordinary" and "many of them were taken in the wild". The author himself states that his main object is to describe the mammals adequately enough for the layman to be able to identify them on sight.

A well-produced and lavishly illustrated volume such as this will appeal to many who will be unaware that it falls very far short indeed of both the publisher's claim and the author's intention. The general plan is based on Simpson's 1945 classification from orders downwards. Most of the subject headings refer only to the subfamily or genus, after the popular name for the group, and very few species are identified by their scientific names. No doubt this reduces technicalities; but the result is a general vagueness, since the reader is often quite uncertain which species of a genus is being discussed. Some large groups of small mammals are dismissed in a few lines on the plea that it is quite impossible to describe them in a limited space.

The standards of accuracy are frequently low. Whether in the form of wild exaggeration, contradictions, taxonomic confusion, unreliable distributional data, surprising colour descriptions, or just unfounded statements of all kinds, mistakes abound to such an extent that it is quite impossible to recommend this book. Space permits of only a few typical examples.

The largest African dormouse is said (p. 128) to be two feet long. The largest specimen I have seen is 12 in. long overall. The masked civet, *Paguma* (p. 170), is said to be nearly four feet long with a tail of equal length. The largest I have measured is 4 ft. 4 in. overall. The ears of the false vampires (*Megadermatidae*) (p. 59) are described as twenty times the size of the head. In the largest I can find, *Macroderma gigas*, the head is 40 mm. long and 20 mm. wide, the ears are 50 mm. long and 65 mm. wide together. The elongated ankle bone of the tarsier (p. 69) is said to be longer than either the thigh or the calf [*sic*]. Actually it is shorter than either femur or tibia. We are told that the squirrel monkey (*Saimiri*) (p. 74) on reaching full maturity may be four times the size of the average adult—a remarkable statement.

Some whales are said (p. 210), while travelling at more than twenty knots ahead of a ship, to dart ahead and "vanish in a second". We are told (p. 204) that more than one of the author's captive grisons "literally burst through overeating". We also learn that two small, short-legged mammals, the brush-tailed porcupine (p. 147) and the armadillo (p. 110), are among the fastest animals on all fours. We read (p. 49) that the hedgehog when alarmed leaps into the air with all four feet to drive its spines into an attacker. The habitually solitary leopard seal is described (p. 158) as migrating "in enormous crowds".

There is often remarkable confusion in taxonomy. The specific epithets of the tamandua (p. 105) and the pygmy anteater (p. 106) are used generically (thus *Tetradactylus* and *Didactylus*). In an attempt to explain the use of the generic name *Panthera* for the great cats, and at the same time to clear up the popular confusion of the terms leopard and panther, Sanderson actually says (p. 162) "all the Great Cats that can roar are now officially *panthers* [author's italics] as the technical name implies". Under the heading Sokhors (*Myospalax*) (p. 122), which is a specialized Chinese rodent forming a separate subfamily, we find a recognizable description of an Indian mole-vole (identified beyond doubt by reference to the Quetta 'mole') of the genus *Ellobius*, a microtine referred to by name on p. 124. There is complete confusion over African otters (pp. 208–209). The spot-necked otter (*Lutra maculicollis*) is described under the name *Paraonyx*, a very different animal, after the statement that *Lutra* does not occur in

Africa. Under hartebeestes (p. 263), having started with Cooke's [*sic*] hartebeeste, we are told at the end of the section "One species is known as the Kongoni". This is, of course, the common name of Coke's hartebeeste!

Some remarkable errors of distribution occur. The grey seal (p. 158), "a shy lone animal", is said to occur no farther south than south Scotland. Both statements will interest those who have studied colonies on the coasts of England and Wales. On p. 162 we learn that the snow leopard is found in Amurland and Sakhalin Island, even down to sea-level in winter. The actual range is the Central Asian mountain region, reports from elsewhere being almost certainly due to confusion with local leopards. We are told that the African zorille (p. 205) is found in North Africa, Egypt, North Arabia, Palestine, Syria, Asia Minor and around Constantinople. In fact, there are no records for any of these areas, and the recognized northern limit is the Sudan. Among the seals, the Hawaiian seal of the mid-Pacific is ignored (pp. 155 and 158), the presence of a hitherto unknown seal in the Indian Ocean is reported (p. 158), but unfortunately without any data, and the distribution, as well as the taxonomy, of the Otariidae is thoroughly confused.

There are many other errors, but only a few can be cited here. The New Guinea three-toed spiny anteater (p. 16) is said to have a naked grey skin; it is actually thickly coated with dense black fur almost hiding the spines. On p. 55 an attempt is made to explain the principle of echo-location in bats; "supersonic" is used for ultrasonic, and the confusion of pitch (vibration frequency) with duration of sound results in complete inaccuracy. The naked bulldog bat (*Cheiromeles*) (p. 62) is said to have a pouch in the skin of the neck "in which the female carries her young". Its occurrence in the male is said to provide for the possibility of twins. But this sac is actually a very small and shallow scent gland structure. What Sanderson does not refer to is a roomy pouch at the junction of the wing membrane with the body, formerly thought by some writers to be for the transport of young, but recently shown to be a sheath for the folded wing tip at rest. The account of the habits of lions (p. 161) has little relation to fact; lions are not terrified of children, they do normally kill more often than once a month, and when not hunting they are not in the habit of "lying down back-to-back with the antelopes". The Bornean civet *Diplogale* (p. 171) is uniformly dark brown, not spotted. Palæontologists will learn with interest that the unfossilized bones of a carnivorous ungulate, the Chalcicothere [*sic*], are found in the soils of East Africa, and that this animal may be the dreaded Nandi bear. Finally, to get the record straight (a favourite phrase of Sanderson's) it should be mentioned that the 11 ft. 5 in. African elephant tusk (p. 293) does *not* weigh 293 lb. It is one of a pair the *combined* weight of which is that figure. The heaviest known tusk is 226½ lb.

Many descriptions indicate that the author has his own colour standards, and in many of the coloured plates the subjects appear to be bathed in the afterglow of a lurid sunset. Plate 98 of a lion is quite unrepresentative of the animal, both in its colour and since it is so obviously a menagerie specimen. Several of the illustrations (many of them old friends) are wrongly titled. On p. 170 the "small-toothed palm civet, *Arctogalidia*", is actually a Burmese palm civet, *Paradoxurus*. Darling's mole rat (p. 127) is a *Cryptomys*, not a *Spalax*. Plate 97 labelled grey seal is a common seal. The illustration on p. 159 is of a male elephant seal, not a female (despite the pup). Plate 146 is a warthog, not a giant forest hog, and Plate 181 shows impala, not Grant's gazelles. Less than 10 per cent of the pictures were taken in the wild; the rest are zoo animals, often posed in artificial surroundings.

Misspellings of scientific names are frequent.

I take no pleasure in directing attention to the many failings of this work, but since quite unfounded claims have been made for it I feel that the opportunity should be taken "to get the record straight". One might almost apply to this book Sanderson's own description of Melville's 'Moby Dick' (in connexion with sperm whales)—"a work of magnificent imagination and almost total zoological inaccuracy".

R. W. Hayman

TALKING ABOUT COMMUNICATION

Studies in Communication contributed to the Communication Research Centre, University College, London

By A. J. Ayer, J. B. S. Haldane, Colin Cherry, Sir Geoffrey Vickers, D. B. Fry, J. Z. Young, R. Wittkower, T. B. L. Webster and Randolph Quirk. Pp. vii+182+9 plates. (London: Martin Secker and Warburg, 1955.) 21*s*. net.

"IF we are to take a hand in developing this process of communication," says Sir Geoffrey Vickers, "we must be able to talk about it; and at present we are ill-equipped to do so. . . . For the underlying issues are screened from us by what is itself a failure of communication. We have no language in which to discuss them with each other; and hence no concepts with which to present them to ourselves." The issues are screened from us, true. But they are screened not by the lack of language and concepts. They are screened by 'Babel'. This volume adds entertainingly and provocatively to the Babel. To be positively and contemporaneously correct, one should call it Meta-Babel.

The reader is given a two-dimensional *hors d'œuvres*: a dozen varieties of meaning of the word 'communication', and at least half a dozen different terminologies in which to discuss them—biological, cybernetic, administrative, neurological, æsthetic, linguistic. The terminology to end all terminologies is provided by the inevitable Prof. A. J. Ayer when he remarks: "It will be seen that there is something here for almost everyone". Prof. Ayer always says many sensible things, but one is never quite sure why he is saying one set of sensible things rather than another; and this sums up one's bewilderment about the book as a whole. One is also bewildered at the extent to which analogy and metaphor are being exploited in this new subject, if it is a subject, of communication. Thus Prof. J. B. S. Haldane writes that "Fruits signal to insects by colour" and also "Fruits advertise themselves to be eaten by mammals and birds". But perhaps these are not intended as metaphors, for he says: "A very large part of biology can be looked at from the point of view of communication theory".

Can communication theory provide a unifying language for the problems of communication?

According to Dr. Colin Cherry (who should know), the "measure of information" of Shannon and Wiener "has nothing whatever to do with meaning, nor with value, nor with usefulness of messages". There seems to be a contradiction here. Prof. J. Z. Young pinpoints the contradiction by saying that "what we still need is a greater unification of our approaches", but "The essence of the scientific approach is the realization that for each purpose we should use a different analogy". Prof. Ayer might have reminded us of the old problem of "the one and the many".

Those of us who enjoyed the hospitality of University College, London, and the stimulus of the oral delivery of these papers, will be glad to have this volume as a record. But a reviewer has a duty to appraise fulfilment of purpose. This is the first publication of the Communications Research Centre—"a first fruit of its activities" says the jacket. These individual essays doubtless contribute to the clarification of the problems of the Centre, and, in their several ways, they make excellent reading; but as a first publication of a research centre this volume puts remarkably little new research on record. This criticism is offered in no captious spirit. All who are alive to the vital importance of communication must have welcomed the establishment of the Centre. One cannot help asking whether this volume is the kind of publication which testifies to the serious research intent of the Centre, or really furthers its object.

G. PATRICK MEREDITH

PROGRESS IN BIOPHYSICS AND BIOPHYSICAL CHEMISTRY

Progress in Biophysics and Biophysical Chemistry
Edited by Prof. J. A. V. Butler and Prof. J. T. Randall. Vol. 5. (Progress Series.) Pp. viii+231+9 plates. (London and New York: Pergamon Press, Ltd., 1955.) 55*s*. net.

THIS volume opens with a review of the reaction patterns of a coliform organism, by A. C. R. Dean and C. N. Hinshelwood. The application of kinetic principles to cellular growth, and the action of enzymes concerned therein, are lucidly surveyed and related to many different processes, of which adaptation and mutation may be mentioned. In their consideration of the physical chemistry of hæmolysis and bacteriolysis by surface-active agents and antibiotics, J. H. Schulman, B. A. Pethica, A. V. Few and M. R. J. Salton are also concerned with the application of physical chemistry to living organisms, particularly microbes. The fact that the enzyme lysozyme brings about a specific depolymerization of the cell walls of certain organisms has resulted in the preparation of protoplasts which, although deprived of cell walls, are capable of metabolizing glucose at the same rate as intact cells. It is clear that the investigation of the unclothed protoplast is likely to be of special value in research on the mechanism of action of substances which influence cellular metabolism.

For obvious reasons, the direct action of ionizing radiation on enzymes and antigens, as discussed by E. C. Pollard, W. R. Guild, F. Hutchinson and R. B. Setlow, is a matter for particular current interest, while for quite another reason the structure and function of the chloroplast (J. B. Thomas) can be of practical interest in a world looking for new sources of energy, of which sunlight is an obvious one for consideration. The theory of X-ray fibre diagrams (A. R. Stokes) is always a subject of some difficulty for the non-specialist, but the discussion given in this book is one that can be followed in general without great difficulty by those not carrying out research in this field. The last contribution in the volume is on recent studies on the reversible denaturation of proteins, by M. Joly. It is natural that Dr. Joly should spend more than two pages discussing possible definitions of protein denaturation and then fail to adopt any simple definition. His ultimate conclusion, that in spite of a certain similarity between all the observed phenomena there exist several types of denaturation and reversal depending on the protein considered and the denaturing agent used, is not unexpected. But it is most desirable that this rather ill-defined state should be discussed and, together with the means whereby it can be brought about, considered in the light of present knowledge of protein structure; this Dr. Joly has attempted to do with some success. It is most unfortunate that the 252 references to the original literature cited by him have been omitted from the main index of this volume owing to an oversight on the part of the publishers. It might have been better to have re-set the index and to have delayed the appearance of the book rather than to publish it with an incomplete index.

This volume adds one more to the many books in related fields which now appear annually and include in their title either the word 'advances' or 'progress'. None of the subjects surveyed in this volume is ineligible for consideration in one of the other annual review volumes; but for those whose special interest is in the application of physical methods to biological problems, there is undoubtedly an advantage in having this collection of articles within the covers of one book.

F. G. YOUNG

THE INSTITUTE OF BREWING

A History of the Institute of Brewing
By W. H. Bird. Pp. ix+139+16 plates. (London: Institute of Brewing, 1955.) n.p.

THE author, who was secretary of the Institute of Brewing until 1951, has produced an interesting and informative book. In 1886, Dr. E. R. Moritz, consulting chemist in brewing, was in the habit of holding informal colloquia; these crystallized into the "Laboratory Club", which published transactions and by 1890 had 250 members. Similar bodies were formed elsewhere, and in 1895 all were federated and later (1903) merged into one—the Institute of Brewing. During 1895–1903 the *Journal* represented its main activity; but further projects were under consideration. The Midland Counties Institute favoured setting up a school of brewing. Agreement was not forthcoming; but the Midland brewers attained their object independently, and the British School of Malting and Brewing at the University of Birmingham resulted (1900).

The essential objects of the Institute of Brewing were defined as the promotion of such sciences and arts as are of practical application to brewing and allied industries, and the dissemination of knowledge useful in such connexion. The whole of the technical personnel of these industries were eligible for membership. Six sections (now also one in Australia) held monthly meetings. In due course committees were set

up to advise on examinations, analysis and, later, research (1918). Since 1922 the Institute has conducted examinations annually on subjects ranging from fundamental physics and chemistry to brewing technologies, engineering, etc.

The research scheme has passed through three phases. At first, problems were investigated in various places by workers maintained there by the Institute: barley at Rothamsted, hops at Wye (new varieties), growing, etc., at East Malling, and the antiseptic constituents at the Manchester College of Technology, nitrogen metabolism of yeast at the Imperial College of Science and Technology, London, and Cadby Hall (J. Lyons and Co., Ltd.), and *p*H in relation to brewing at W. Younger's and Tetley's breweries. At this time a research organizer coordinated the work. In 1934 all laboratory work except that on hops was concentrated in the Birmingham Brewing School, all the studies being supervised by committees already in being. Finally, after many setbacks, a director was appointed, and all the work was transferred to the present Brewing Industry Research Foundation at Nutfield (1951). This is still the Institute's research scheme, financed on a vastly greater scale.

During the Second World War, contributions to the national effort included experimental work on the use of oats, flaked barley, lupulin, surplus yeast, concentration of beer, pest infestation of barley and vitamins of the B group in beer. A final contribution to brewing science and education has been the Institute's membership and support of the European Brewery Convention (1947).

The book has eight appendixes recording the names of officers of the Institute and forty-nine photographs of some of these and of scientists who have contributed to its success. The index is very comprehensive.

R. H. Hopkins

RESEARCH ON TUBERCULOSIS AND LEPROSY

Experimental Tuberculosis

Bacillus and Host. With an Addendum on Leprosy. Edited by G. E. W. Wolstenholme and Margaret P. Cameron. (A Ciba Foundation Symposium.) Pp. xii+396+24 plates. (London: J. and A. Churchill, Ltd., 1955.) 42*s*. net.

PRESENT-DAY research in tuberculosis and leprosy continues to attract investigators of widely different disciplines, each interested basically in a limited aspect of the subject regarded from his own scientific point of view. There is thus a danger of the study of these important diseases becoming fragmented into entirely separate domains of chemistry, pharmacology, pathology, bacteriology and immunology. One of the most valuable contributions of the Ciba Foundation is its rare facility for organizing symposia in which all these separate approaches to what is fundamentally one coherent study can be blended. Reports which would normally be heard only by workers of the same scientific background are here presented in an informal atmosphere for consideration by those equally expert in other branches of the selected subject. Thus, in the published symposia, the most striking feature is not the undoubted excellence of the main contributions, but the unusually stimulating discussion on each paper, which is reported verbatim. In a symposium of this type there is far less preoccupation with specialized knowledge than is usual at any sectional meeting; the exchange of ideas, and the cross-fertilization of one speciality by another gain considerably in the process.

The present symposium begins with a series of papers on the chemical structure of Mycobacteria and the biological activity of various fractions of the bacterial protoplasm. The emphasis here may seem perhaps a little overwhelmingly academic to the medical research worker. However, a very large volume of work is skilfully compressed into short readable accounts, and the implications and objects of the researches are well brought out both in the discussions and in the well-balanced progress of the programme. In the next section attention is gradually focused on the host animal—how the tissues respond to the infecting organism, and which bacterial fractions are important in eliciting such response. Here both hypersensitivity and immune reactions are considered. Equally important is a complementary study of how the bacilli themselves may be affected by biochemical reactions of the host animal. Some of the factors concerned in resistance to infection are illustrated by *in vitro* studies with infected tissue cultures, and by observations of the immunity of animals previously exposed to non-lethal infections; indirect evidence obtained by interference with the normal host–parasite relationship by cortisone or by chemotherapy is also presented. In the addendum on experimental leprosy, the common denominators in the two diseases and in the tissue responses of the infected host to either organism are underlined.

In a symposium of this size, it is perhaps invidious to select individual contributors for special mention. It suffices to say that, whatever the special interest of the reader, here he will find his acknowledged leaders; however well he considers he 'knows the literature', he will still learn much from reading each contributor undergoing the only satisfactory test—trial by his peers.

Derek Hobson

METEOROLOGY OF THE FALKLAND ISLANDS AND DEPENDENCIES

The Meteorology of The Falkland Islands and Dependencies

By J. Pepper. Pp. vi+249. (London: Crown Agents for Oversea Governments and Administrations, 1954.) 42*s*.

THIS large, beautifully produced book contains a discussion and tabulated summaries of the surface meteorological observations made between 1944 and 1950 at Port Stanley, Falkland Islands, and at nine stations in the Dependencies constituted by the Graham Land Peninsula on the Antarctic Continent and the islands in the Antarctic Ocean to the north of Graham Land. The station farthest south, Marguerite Bay on Graham Land, is some nine hundred miles from Port Stanley. All are at or near sea-level. Besides meteorological data, the book includes a description of the sea-ice variations observed in 1950.

The Dependencies stations, except for the one at South Georgia operated by an Argentine whaling company until 1949, were originally set up by the

Royal Navy in 1943–44, and since 1950 they have formed part of the Falkland Islands Dependencies Survey Meteorological Service, which has its headquarters at Port Stanley and performs all the usual functions of a meteorological service, including weather forecasting. The book, which was prepared in the Climatological Division of the Meteorological Office, is in three parts: a general discussion, written by Dr. J. Pepper; a gazetteer of stations; and climatic tables.

The publications of the meteorological work on Antarctic expeditions include some of the classics of meteorology but, on the whole, they are restricted in time and space. This is the first publication to survey the weather of a large area of the Antarctic for so long a period. The weather of the area is controlled by the continual passage of depressions and the intervening ridges of high pressure; and so it is very changeable, with relatively small seasonal variations but large changes associated with the passage of fronts. Mean pressure is low—about 900 mb. at the Dependencies and 1,000 mb. at the Falklands. Mean monthly temperature varies between about 35° F. in summer and 15° F. in winter over the Dependencies, and 48° F. in summer and 35° F. in winter at the Falklands. Rises and falls of temperature of up to 40 deg. F. occur in the Dependencies with the passage of warm and cold fronts respectively. An interesting comparison with northern-hemisphere stations at the similar latitudes and situations (for example, Godthaab in Greenland) shows the Antarctic ones to have warmer winters and cooler summers, demonstrating the more intense circulation of the Antarctic. Interesting details are the very high frequency of visibility exceeding 40 km. and the 'burning' of sunshine cards at solar elevations less than 2°—exemplifying the purity of the air—the observation of iridescent clouds by moonlight, and the exactness with which the rise of temperature in air descending from the 5,000-ft. plateau to Marguerite Bay corresponds to the adiabatic value.

The tables include monthly summaries of all the meteorological elements, and frequency tables for many of them for all the stations. Special praise must be given to the gazetteer, with its photographs and detailed topographical descriptions. It is regrettable that no index is provided.

OPTIMAL SPAN OF WORKING LIFE

Ageing in Industry

An Inquiry based on Figures derived from Census Reports into the Problems of Ageing under the Conditions of Modern Industry. By F. Le Gros Clark and Agnes C. Dunne. Pp. xi+149. (London: The Nuffield Foundation, 1955.) 6*s*.

THE only people who seem to have solved the problem of their senescent members seem to have been the mythical Hyperboreans whose aged, when they wished to retire from life, performed a "joyful suicide" by decking themselves with garlands and precipitating themselves from a rock into the sea. Non-mythical peoples have found various other solutions. The Tibarini used to hang their old on gibbets, the Hircanians and Bactrians cast them, while still living, to the dogs, and the Scythians buried them alive.

In Great Britain such drastic measures have never been contemplated, although the plight of the aged has often given cause for much distress. During the past two or three decades we have become increasingly conscious of the wider repercussions of our ageing population and the resulting social and economic disadvantages. The highly complex situation was fully examined by the Royal Commission on Population (1949). The Commission's report was particularly concerned with the growing 'burden of dependency', that is, the decline in the proportion of producers per consumer, and it emphasized the desirability of prolonging the productive capacity of workers beyond the age of sixty-five. At that time, however, it was not possible to give anything like a precise answer to the question: "At what ages are men compelled, by reason of their age alone, to leave the occupations in which they have spent their working lives?" This is the important question to which Mr. F. Le Gros Clark and Miss Agnes Dunne address themselves in this book. Their inquiry is based on figures derived from the Census Reports for 1921, 1931 and 1951 and relates to four million men in thirty-two occupations, representing about a quarter of the occupied male population of Britain in 1951. The principal method of analysis employed by them is that of the 'moving cohort'; they have taken a decennial age-group from each of the thirty-two occupations at 1921 and followed it through until 1951.

They define the 'survival-rate' of working men as the proportion of men who reach their mid-sixties in a given job and are physically capable of remaining in it until their late sixties or beyond. The survival-rates for the different occupations range from 75–85 per cent among watch- and clock-makers to 5–15 per cent among workers at the coal face. Agricultural workers and men in certain building trades have relatively high survival-rates as compared, for example, with tobacco workers, compositors, foundrymen, bus conductors and constructional engineers. By appropriately weighting the thirty-two occupations and making allowance for the proportion who would have to cease work because of impaired health, the investigators estimate that alternative jobs would have to be found for 20–30 per cent of those aged 55–64 in 1951. For the country as a whole, this amounts to forty thousand alternative jobs to be found every year over the relevant ten years.

A second analysis shows the ratio of those aged 65 and over to those aged 35–64 in each of the thirty-two occupations. This reveals considerable variation between the occupations in respect of their employment of older men, a variation which suggests an incapacity on the part of many workers to remain in certain occupations under present conditions. In a third analysis the investigators show the changes in age structure of the occupations which took place between 1931 and 1951 in relation to the contraction or expansion of the occupation.

This is a most valuable study which will provide industry, the trade unions and many government departments with much-needed food for thought and perhaps a first guide to action. The authors' efforts will not have been in vain if their report leads at least to serious research into possible alternative jobs for older people and into methods of reducing the stresses which make them leave their work at an age earlier than they might otherwise do. The Nuffield Foundation has rendered another public service in sponsoring this report.

JOHN COHEN

The Pathogenesis of Poliomyelitis

By Prof. Harold K. Faber. (American Lecture Series—No. 257. A Monograph in American Lectures on Pediatrics.) Pp. xvi+157. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, 1955.) 36*s*.

EXACTLY where the virus of poliomyelitis first invades the body has long been the subject of speculation, as also has the problem of its subsequent dissemination. These topics have for many years afforded a fruitful field for collaboration between anatomists and pathologists. The concept of the axonal transmission of poliomyelitis, first clearly formulated by Fairbrother and Hurst in 1930, soon met with the approval of Prof. H. K. Faber, who has staunchly advocated it ever since. The present work is a re-statement of his views, in the face of evidence which in recent years has appeared to cast doubt upon them.

His main thesis is that virus first enters the mucosa of the mouth and pharynx, and then spreads centripetally along the axons of sensory nerves to reach their ganglia, in which 24–48 hr. after exposure it begins to multiply. Two to three days later, the virus then reverses its direction and passes centrifugally to be excreted into the oropharynx, whence axonal re-invasion with further centripetal spread of virus may occur, while in addition varying amounts of virus are swallowed. Virus particles in the intestine, he suggests, may be absorbed in exactly the same way as undigested protein; and only thus do they reach the liver, or the intestinal and mesenteric lymphoid tissue, and the blood stream. Virus obtains access to the central nervous system either from the blood stream, or from the peripheral ganglia if they are severely infected.

Prof. Faber considers that the tissue culture experiments of Enders and his colleagues have no relevance to his argument. For though they showed that virus in tissue culture could grow outside the nervous system, and possibly in the complete absence of nervous tissue, Faber maintains that conditions *in vitro* and *in vivo* are fundamentally different. It is all the more surprising that he does not mention the experiments of German and Trask, which are especially pertinent in this connexion; nor does he seriously consider the possibility of cellular transport of virus mediated through the lymphoid tissues.

J. M. Yoffey

A Manual of the Dragonflies of North America (Anisoptera)

Including the Greater Antilles and the Provinces of the Mexican Border. By Prof. James G. Needham and Prof. Minter J. Westfall, Jr. Pp. xii+615. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1955.) 94*s*. net.

MORE than twenty-five years after the publication of his earlier book on the dragonflies of North America, Prof. J. G. Needham, in collaboration with Prof. M. J. Westfall, has now written the first part of a new and enlarged work, dealing with the sub-order Anisoptera. The need for it is evident from the fact that, since his first work, the list of species in the North American Anisoptera has grown from 245 to 332.

Most of the book naturally deals with the taxonomy of the group, but there are chapters devoted to the structure and life-history of the Anisoptera, to the methods employed for collecting adults and nymphs and for studying them in the field and laboratory. In the systematic part, keys and tables are given for the identification of families, genera and species (both adults and nymphs, where known), and under each species are given not only a description but also the principal bibliographic references, distribution and the period of flight of the adults.

The whole book is lavishly illustrated with line and half-tone illustrations of venation, genitalia and nymphs, all of a high level of excellence. Most of the photographs were taken by Prof. Westfall and were produced by the methods outlined in a joint paper with A. L. Smith (*J. Biol. Phot. Ass.*, **19**, No. 2, 74; 1951). The manual will certainly be of great value, not only to American students of Odonata but also to others interested in these flies, and the publication of the companion volume on the Zygoptera, which is in preparation, is eagerly awaited.

D. E. Kimmins

Optical Instrumentation

Edited by Prof. George S. Monk and W. H. McCorkle. (National Nuclear Energy Series: Manhattan Project Technical Section. Division 4—Plutonium Project Record: Vol. 8.) Pp. xxv+262. (London: McGraw-Hill Publishing Company, Ltd., 1954.) 30*s*.

THIS book is not of sufficient quality to justify the claim that it may be used as a text-book. The editorial advisory board finds it necessary to warn the reader to expect discrepancies and duplication on the plea that promptness of publication seemed more important: this is scarcely a recommendation for a reference book. Even so, it is a little too much to find that a smoke tester mentioned on p. 49 as being developed for particles 0·04 cm. in diameter is actually intended for particles $\frac{1}{4}\mu$ diameter according to paper 5.2 (not paper 5.3 as given by the reference). This paper makes the illuminating statement that cigar-smoke is the limit of precision of the method—the reader being left to draw his own conclusions. Techniques are mainly experimental and restricted both by time and to available lenses. It is thus not surprising to read on p. 15 "the best definition was not always obtained".

Theory is but briefly considered. In section 1.2, on brightness of images, it is stated that if the size of the entrance pupil is sufficiently larger than the exit pupil to compensate for light losses in the system, the intensity of a point object will be increased. The influence of the diameter of the pupil of the eye is not discussed. The book is not without interest, however: the problems encountered are outlined; the replacement of optical glass, darkened by high-energy radiation, by plastics is mentioned; and some valuable work on evaporation in vacuum is recorded.

G. W. Hamstead

The Ocean Floor

By Hans Pettersson. (Silliman Memorial Lectures.) Pp. xv+181. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1954.) 3 dollars; 24*s*. net.

ALTHOUGH the sea-floor covers approximately two-thirds of the Earth's surface, our knowledge of its morphology, structure and composition is meagre. For many years after the *Challenger* Expedition (1872–76) there was little progress, largely due to the lack of improved apparatus for investigating the deep-sea floor. Although the *Challenger* took cores 2 ft. in length, there was little improvement until Dr. B. Kullenberg, during the Second World

War, developed a piston core-sampler capable of taking cores 60 ft. in length. Prof. Hans Pettersson, realizing the significance of this and other recently developed geophysical techniques, organized with great success the Swedish Deep-Sea Expedition (1947–48).

This book, based on Prof. Pettersson's Silliman Lectures at Yale University, is a fascinating description of the scientific results of the Expedition, together with a summary of the results of other recent expeditions. Few technical terms have been used, and the book is intended for the non-specialist. The author's style is vigorous and clear, and his critical examination of theories is of great interest. There is an interesting chapter on deep-sea radium and the geochronology of the ocean floor. Since Pettersson's pioneer work on radium determinations, published in 1930, a possibility has existed of developing a time-scale for deep-sea cores based on radioactive decay. Piggot and Urry were first in this field. It would now seem from the detailed radium, ionium and uranium measurements that the problem is far more complicated than suggested by the investigations of Piggot and Urry.

J. D. H. Wiseman

Birds and Mammals of Shetland

By L. S. V. Venables and U. M. Venables. Pp. xii+391+8 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1955.) 30*s*. net.

THIS is an ambitious book, the authors setting themselves the formidable task of describing the birds and mammals of that interesting northern group of islands known as the Shetlands; not content with this wide field, they give appendixes on the introduction of the common frog and common toad to Shetland, and they wind up with a list of plant flowering dates.

The volume begins with a short account of Shetland naturalists and visiting naturalists, goes on to consider Shetland habitats and then proceeds to status changes in Shetland birds. It is obvious that the authors take a keen interest in the waxing and waning of species and have found these islands an excellent place for population studies. After this, they work through the list of Shetland mammals and follow with the birds, dealing with them species by species in a very thorough manner.

They are to be congratulated on a painstaking effort and on a book that will be of much assistance to visitors to the islands. Frances Pitt

Introduction to Virology

By Dr. Gilbert Dalldorf. Pp. ix+102. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, 1955.) 25*s*.

DR. GILBERT DALLDORF'S little book sets out to tell the practitioner and hospital pathologist the simpler facts about viruses and virus diseases of man. His hope is to convince them that virus infections can be studied, from the routine and even the research point of view, with the aid of comparatively simple equipment. He is very right to try to dispel the notion that it is an esoteric subject, only comprehensible to a select few. The commoner virus diseases are discussed from the clinical and laboratory aspects. Measles and chicken pox appear, oddly enough, under skin diseases and not under "Poxes and Rashes". "The Simple Common Techniques" are described, but scarcely in sufficient detail to allow of their being performed without reference to larger works, and unfortunately there are very few references. The word "subspecies" is used erroneously on p. 11; and on p. 59 and again on p. 87 the author makes the astonishing statement that latent infection with herpes simplex virus occurs frequently in normal rabbits.

Michelangelo

A Study in the Nature of Art. By Adrian Stokes. Pp. 154+24 plates. (London: Tavistock Publications, Ltd., 1955.) 25*s*. net.

THIS book is of somewhat unusual character, and perhaps valuable on that account. It is a brave effort to get beneath the surface of a tempestuous and majestic personality, that of Michelangelo (1475–1564). Unluckily, the author's style is often so obscure as to baffle the reader considerably, even if he is able and willing—as many readers will be—to see their subject in terms of Freud's psychology. The advantage, however, of this analytical study is, of course, that the basic nature of art—as a sensitive function of environment—is revealed stripped of adventitious material and is thus of æsthetic significance.

After some introductory matter, there is a discussion of the master's visual works, followed by an able analysis of his poems. There are copious notes, and a couple of appendixes, one concerned with iconography and the other with the Medici chapel. In addition, there are several illustrations.

All this leads to an appraisal of the unique contribution of Michelangelo to humanist art. Painting, sculpture, architecture, all bore witness to this tireless mind, melancholic and 'prickly', wearing itself out in superhuman feats of bodily endurance. His mannerisms were rugged, and as Lomazzo declared in 1590, Michelangelo reached the knowledge of harmonic proportions by way of music. Even his own body (on this showing) was built harmonically.

F. I. G. Rawlins

B.B.C. Handbook, 1956

Pp. 287. (London: British Broadcasting Corporation, 1955.) 5*s*.

THIS handbook, besides giving a general picture of broadcasting in Britain during the year ended March 31, 1955, and lists of representative programmes broadcast during that period, constitutes a very convenient reference work on the B.B.C. as well as a guide to its working. An account of the constitution is followed by notes on controversial and political broadcasting, and compared with last year's handbook there are fuller accounts of the External Services and of the re-broadcasting of the B.B.C. programmes throughout the world. More information is also included about the advisory councils and committees. Of particular interest to the scientist are the section describing the work and responsibilities of the Engineering Departments and that discussing some problems of reception, particularly very high frequency.

Details are given of the membership of the various councils and committees and of the senior staff, the balance sheet and accounts for the year, some analyses of income and expenditure, and tables of the totals and distribution of broadcasting licences, etc. The handbook includes the text of the royal charter, licence and agreement; and a good bibliography and index add to its value as an accessible and comprehensive source of information on the B.B.C. and its activities.

CYTOLOGICAL IDENTIFICATION OF RADIATION-CHIMÆRAS

By Dr. C. E. FORD, J. L. HAMERTON, D. W. H. BARNES and Dr. J. F. LOUTIT
Medical Research Council Radiobiological Research Unit, Atomic Energy Research Establishment, Harwell, Berks

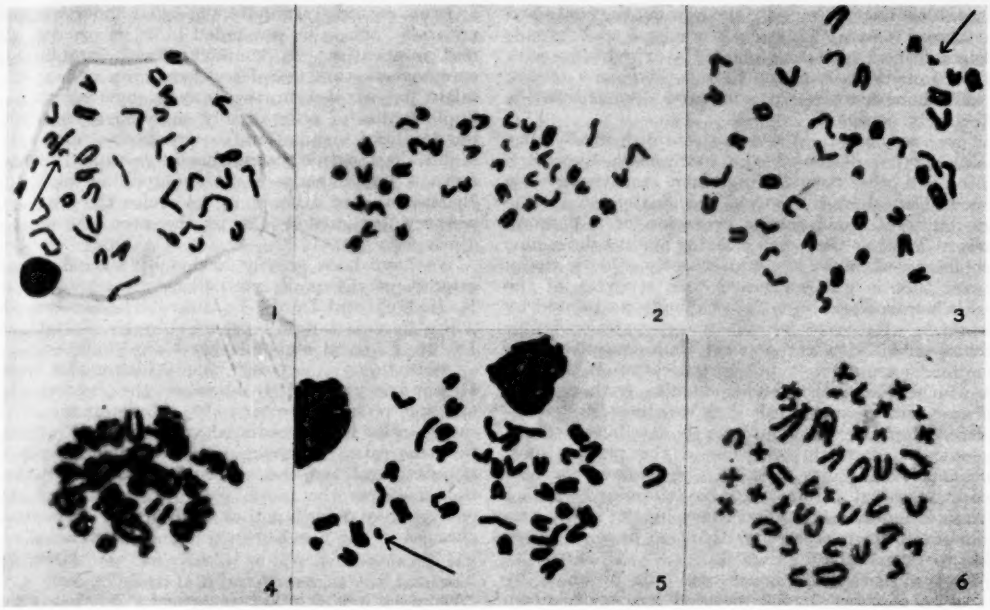
THE term chimæra, long used in botany, has recently been adopted by zoologists to denote an animal the constituent cells of which are of more than one genotypic or antigenic lineage. The state may occur naturally, as the freemartin in cattle. An example has even been reported in man[1]. It may be induced by the injection of foreign cells into the developing fœtus[2]. In all these instances it is believed that cells from one individual are grafted into another during fœtal life when the immunological mechanisms are immature. In these circumstances the natural and the foreign stock appear to be able to develop side by side. After the birth of the animal the effect of administering homologous cells or tissues changes and the homograft reaction occurs; following a preliminary 'take', the host develops an immune response and as a result sheds the graft.

It has been shown by Jacobson *et al.*[3], and soon after by Lorenz *et al.*[4], that adult mice irradiated with an expectedly lethal dose of X-rays could recover if grafted or injected with hæmopoietic tissue from a normal mouse. Consequently it was not surprising that they postulated recovery to be due to a 'humoral' or chemical factor in the material given, rather than to replacement of the damaged tissues of the host by foreign cells. Furthermore, Lorenz and his group showed that even heterospecific material from guinea pigs and rats could in some circumstances produce a similar result[5,6]. No example of the compatibility of a heterograft had been recorded, so the humoral theory seemed almost established. It received additional support from the investigations of Cole and his collaborators[7], who showed that homogenates in which the splenic material had been subjected to severe trauma were as effective as suspensions. On differential centrifugation of these homogenates the active fraction was the heaviest, consisting almost wholly of nuclei. The activity of this fraction was destroyed by solutions of crystalline deoxyribonuclease and trypsin, which were believed to act specifically on naked nuclei and not to damage any intact cells which might have been left after homogenization[8]. Cole and Ellis[9] considered the active principle to be macromolecular, particulate and probably deoxyribonucleoprotein.

On the other hand, there are the observations from our laboratory. Inbred mice irradiated and treated with homologous cells survive for short periods only compared with similar mice given isologous cells[10]. The material used for injection, normally very labile, is preserved by glycerol at −79° C.[11], as are some cells; and prior administration of homologous cells to elicit an immune response destroys the therapeutic effect of a second, post-irradiation injection of identical material[12]. When a single injection of homologous cells is made after irradiation, the donor's antigens persist and apparently increase in the host, and antibodies previously induced in the donor appear in the host and increase in titre (Mitchison, N. A., unpublished work). Recent experimental results obtained in the United States point in the same direction. A mixed population of erythrocytes with antigens derived either from host or from donor appears in the peripheral blood of irradiated rats given homologous bone-marrow[13]. Also, irradiated mice treated with homologous cells will tolerate selected skin grafts which normally they reject[14]. These experiments collectively give very strong support to the hypothesis that the damaged hæmopoietic tissues of the host are replaced by the injected foreign cells or their descendants. They fall short of proof, however, since they do not exclude the possibility that immunological properties may be transferred by a process akin to transduction in bacteria.

This objection would be overcome if dividing cells with one or more distinctive chromosomes characteristic of the donor could be identified in the host. The possibilities of such an experimental approach had long been appreciated in principle. The problems were technical and complementary; first, to find a suitable chromosome-marker, and second, to make preparations of a standard which would enable it to be recognized. There are forty chromosomes in a normal mouse. They show little differentiation, varying continuously in length and all having effectively terminal centromeres[15,16]. The sex chromosomes cannot be identified in somatic mitoses by present methods. It seemed, therefore, very unlikely that a satisfactory marker could be found in the mouse. However, in the course of a survey of the cytological properties of a series of semi-sterile stocks raised by Carter, Lyon and Phillips[17], one stock (*T*6) was found to be heterozygous for a very unequal reciprocal translocation between two of the smallest members of the normal chromosome-set. One of the two re-arranged chromosomes was thus much smaller than any of the normal complement and showed up prominently in spermatogonial metaphases. A potential marker having been obtained, the next step was to develop a really satisfactory technique for making preparations of bone-marrow. This proved more successful than had been anticipated and will be described elsewhere. It is sufficient to say here that it is an adaptation of the Feulgen-squash method, in which colchicine pretreatment is used and the tissue is handled as a cell-suspension. The small marker chromosome was found to be even more distinctive in bone-marrow cells than in spermatogonia (Fig. 1). It usually appears as three dots arranged in a triangle, suggesting the presence of an under-stained ('heterochromatic') region close to the centromere. Similar under-stained regions are found in five other chromosomes of the normal set. The chromosomes of a cell in metaphase from the bone-marrow of a normal *CBA* mouse are shown in Fig. 2.

Male *CBA* mice were used for the experiments. They were exposed to 950 r. of X-rays and then injected intravenously with a cell suspension prepared from the spleens of infant mice heterozygous



All the photographs are of cells in metaphase from bone-marrow, except Fig. 5, which is from spleen. Arrows point to the marker-chromosomes. Magnification × 960, except Fig. 4. Fig. 1 : *T6*/+ mouse. Marker-chromosome present. Fig. 2 : Normal *CBA* mouse. No marker-chromosome. Fig. 3 : *T6*/+ cell in *CBA* mouse 14 days after irradiation (950 r.) and injection with *T6*/+ cells. Fig. 4 : *CBA* mouse 5 days after irradiation (950 r.) and injection with *T6*/+ cells. Host cell showing dicentric chromosomes and acentric fragments. × 1120. Fig. 5 : *CBA* mouse 28 days after irradiation (950 r.) and injection with *T6*/+ cells. *T6*/+ cell in spleen. Fig. 6 : *CBA* mouse 19 days after irradiation (950 r.) and injection with cells from rat bone-marrow. Cell with normal rat chromosomes

for the *T6* translocation. Eight animals in all have now been killed, at 5, 14, 19, 28 and 49 days after injection, and in every one the characteristic *T6* marker-chromosome has been found in dividing cells of the bone-marrow. A typical cell from an animal killed 14 days after injection is shown in Fig. 3. In such a cell it is possible to count the chromosomes accurately and to be quite certain whether the marker-chromosome is, or is not, present. Cells descended from those injected are in any event positively identified by the marker-chromosome, whether the chromosomes are countable or not. A disadvantage inherent in the squash-technique is that one can never be quite sure when a cell has been broken and some of the chromosomes lost. The firm identification of a host cell therefore requires the presence of a full and normal set of mouse-chromosomes (that is, a count of 40 and no marker). No such normal cell has yet been found. However, structural changes of the kinds well known to be induced by irradiation have been observed in a few cells. It is reasonable to attribute these changes to the high dose of radiation delivered to the host-animal and so to identify the cells containing them as host cells. An example is shown in Fig. 4. This cell is broken and only thirty-six of the centromeres can be accounted for. Nevertheless, eight dicentric chromosomes, fourteen acentric fragments, and four pairs of minute (isodiametric) fragments were found. It may be noted in passing that if a cell such as this is able to complete division the daughter-cells would be so unbalanced genotypically that the possibility of their survival must be very remote.

The marker was readily identified in the great majority of cells with well-spread chromosomes. Many of these cells contained forty chromosomes ; none had more ; some had less. Most of the latter had clearly been broken during the making of the preparations. The relatively few cells lacking a marker had counts of less than forty. In addition, dividing cells with chromosomes insufficiently spread for accurate counting were present in all preparations. The marker was identified in many of these also, although a careful search was often necessary. No essential difference was noted between animals killed at different times. These results show that at least a large part of the host's bone-marrow had been replaced by cells originating from the donor, and that there is no evidence of recovery of the host's own tissue even seven weeks after injection.

Dividing cells containing the marker-chromosome have also been identified in spleen (Fig. 5), lymph node and thymus. The information for these tissues is not yet as extensive as for bone-marrow. Nevertheless, it suggests that the situation in these organs is essentially the same, that is, virtually complete replacement of the host's tissue by donor-cells. It is significant that, in comparable experiments, Mitchison (unpublished work) found antigenic activity attributable to the donor to be present in spleen and lymph node for as long as seven weeks after injection.

One series of irradiated mice was injected with a suspension of bone-marrow cells of the Wistar rat and killed 5, 11 and 19 days afterwards, two at each time. Dividing cells with normal rat-chromosomes were easily identified in bone-marrow from all the animals (see Fig. 6). The chromosome complements of the rat and the mouse are strikingly different, and almost all cells at metaphase could be firmly identified one way or the other. Of 1,400 cells examined, none was identified as a mouse-cell and only fifteen were

classed as uncertain; all the remainder contained rat chromosomes. This result confirms and extends the conclusion to be drawn from the experiments with the *T*6 marker, namely, that replacement of the host's bone-marrow by injected donor-cells is effectively complete.

These results would seem to establish finally that cellular repopulation is the mechanism by which spleen and other tissues bring about their therapeutic effect. They do not, however, specifically exclude the possibility of simultaneous operation of a humoral factor. The role that such a factor might take is now problematical, since it could scarcely still be maintained that it was concerned with recovery of the host's hæmopoietic tissue, as originally postulated by Jacobson. Recovery by cellular repopulation is not incompatible with the reports that suspensions of free nuclei are active; but consideration of the way in which free nuclei might exercise a therapeutic effect is unnecessary until it is conclusively demonstrated that the action cannot be attributed to the presence of some intact cells in the preparations. Although the main question, we believe, is now firmly answered, it remains to be determined whether there is some measure of recovery by the host's own cells at an even later stage than we have yet been able to examine.

That a therapeutic effect could be obtained by injection of heterologous material has been known for several years[5,6]. In fact, this was at one time considered by some workers to be almost decisive evidence in favour of the 'humoral' hypothesis. Those who preferred the alternative view must have been prepared to accept the unorthodox concept of the co-operation, at least temporarily, of the cells of two distinct species in one individual. Although the very term chimæra points to the antiquity of the idea, it is believed that the experiment reported here provides the first decisive evidence in animals that normal cells of one species may, in special circumstances, not merely survive and multiply in another, but even replace the corresponding cells of the host and take over their functions.

The possible applications of the chromosome marker technique are worth noting. In principle, it provides a biological 'tracer' method which should be applicable to all questions where the origin in development or regeneration of a particular group of cells is at issue, provided the cells concerned undergo mitosis naturally, or can be persuaded to do so. It may also find applications in connexion with problems of carcinogenesis and transferred immunity. The method might be applied in two ways: by injection or implantation of cells already carrying a marker, or by localized irradiation to produce a detectable, viable chromosome rearrangement *in situ*. The latter method has already been employed in plants by Brumfield in an attempt to determine the number of primary generative cells in the root meristem of *Vicia faba*[18].

We have been greatly helped by the advice and interest of many of our colleagues, especially Dr. R. H. Mole and Dr. E. V. Hulse. The heterozygous *T*6/+ mice were kindly provided by Dr. T. C. Carter, Dr. M. F. Lyon and Miss R. J. S. Phillips.

Addendum. A report[19] received after this manuscript was completed describes the detection of alkaline phosphatase activity characteristic of the rat in cells from irradiated mice injected with rat bone-marrow. Although the authors regard repopulation of the host's bone-marrow by cells from the donor as the most likely explanation of their results, they point out that induction of the observed changes in the host's own cells is not excluded.

[Dec. 29

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THE *ATLANTIS* MARINE GEOLOGICAL EXPEDITION TO PERU AND CHILE

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THE research vessel *Atlantis*, of Woods Hole Oceanographic Institution, explored the deep trenches that lie off the coast of Peru and northern Chile during November and December 1955. The expedition collected a hundred cores of sediments along twelve profiles between Talara in lat. 5° S. to a point eighty miles south of Antofagasta, Chile, in lat. 25° S. Continuous soundings of the water depth were made with the new Woods Hole sensitive sonic sounder whenever the ship was under way. In addition to the profiles on which sediments were collected, six traverses solely for sonic sounding were made across the deepest part of the trenches. Numerous bathythermograph readings were made of the Humboldt Current, and twelve runs were made with the geomagnetic electrokinetograph south of Iquique, Chile, in lat. 20° S. in an effort to determine the strength and character of the Humboldt Current. These are among the first runs of this character that have been made south of the magnetic equator, which passes near Lima, Peru. The results have not yet been calibrated to indicate the actual character of the current.

One of the most interesting features of the Expedition was the delineation, by means of the sonic sounder, of a trench 500 miles in length and one to

three miles wide, and 24,000–26,000 ft.—mostly more than 25,000 ft.—deep extending between Arica in lat. 19° S. and lat. 25° S. The sides of this trench in each of the seven places where it was crossed are remarkably steep and range in height from 1,000 to 4,000 ft. In one place in lat. 25° S., the wall of the trench, as indicated by the fathometer trace, rose 1,500 ft. in a quarter of a mile. This trench was only forty miles from shore at this locality. The trench is balanced by mountains 20,000 ft. high scarcely 125 miles away. North of lat. 19° S. this trench is shallower and evidently is offset on echelon by a shallower trench to the west.

The sea floor seaward from shore descended more or less progressively to the bottom of the trench. In many places remarkably flat benches were observed in water from a few hundred to several thousand feet deep. These benches in places were terminated by more or less pronounced scarps, some of which were steep and as much as 5,000 ft. in height. Seaward from the deepest part of the trench the bottom rises more or less progressively upward to a depth of 2,200–2,000 fathoms. The tracings of the sonic recorder give the impression that the deep trench represents a graben within other downfaulted blocks, such as is found in the Red Sea.

A profile was run parallel to the coast between lat. 12° S. and 26° S. in shallow water. One large submarine canyon with walls 3,000 ft. in height was found. It is located a short distance north of Arica, about lat. 18°. Elsewhere only occasional minor notches are observed in the profiles parallel to the coast.

The primary objective of the Expedition was to study the sediments. The deepness of the troughs suggests that the area represents a geosyncline in the making. The land that is the source of the sediments for the area is arid and supplies relatively little sediment to the sea. It is hoped that the results will throw light on the origin of greywackes. Details of sedimentation cannot yet be given as the sediments were kept in the core tubes until return to the laboratory; but many of the samples, particularly in water of shallow and intermediate depth, consisted of muddy sands strongly suggestive of greywacke. Certainly the pattern of sedimentation does not accord with the concept of increasing fineness from shore. In many places the sediments at some distance from shore are much coarser than those nearer the coast. The deep samples consisted of clays in all cores except one, which was sandy. The cause of the variation in texture is not apparent from the field-observations. Perhaps bottom configuration is a factor.

Three cores were placed in a refrigerator as soon as collected to prevent decomposition of possible hydrocarbons. It is hoped that studies of the organic content of these frozen samples will throw light on the origin of oil.

The Expedition was conducted under the auspices of Woods Hole Oceanographic Institution of Woods Hole, Massachusetts. The Esso Research and Engineering Co. and Socony-Vacuum Laboratories have also contributed to the support of the project. The Esso Research and Engineering Co. hopes to assist with the studies of the hydrocarbon content of the sediments. Henry C. Stetson, research oceanographer of Woods Hole Oceanographic Institution and Alexander Agassiz Fellow in Oceanography, Museum of Comparative Zoology, Harvard University, was chief scientist in charge of the Expedition until his unfortunate death at sea on December 3. Parker D. Trask, research associate of Woods Hole Oceanographic Institution and lecturer in geologic engineering of the Department of Engineering of the University of California, was chief scientist for the remainder of the trip. Other members of the scientific staff included Bernhard Kummel, associate professor of stratigraphy and palæontology, Harvard University, and the following staff members of Woods Hole Oceanographic Institution: William D. Athearn, Robert Lufburrow, Herbert Small and John Zeigler. Victor Benavides, geologist of the International Petroleum Company of Peru, Lieut. Jose Carvajal of the Peruvian Navy, and Jose Stuardo of the Chilean Marine Laboratory at Valparaiso, also participated in the work.

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RESEARCH STUDENTS IN THE UNITED STATES OF AMERICA

By H. N. V. TEMPERLEY
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THIS article is written after three extended visits to the United States. I spent seven months at Yale, a whole academic year at the University of Nebraska and about six months at the Bureau of Standards, Washington. In addition, I made shorter visits to about fifteen other universities and research institutions. In Britain I have had a total of about ten years experience in directing small research groups in the Admiralty and at Cambridge.

So far as physics and chemistry are concerned, it seems to me that standards for a Ph.D. degree do not vary greatly as between different universities, nor are there very wide differences as between Britain and the United States. It is widely recognized by employers that these letters guarantee a considerable innate ability and capacity for hard work. It is, I think, fairly generally agreed that the American freshman is not nearly so well prepared for college as is his English cousin, but some of the difference has already been made up at the 'bachelor' stage, because of the fact that the degree course lasts four years instead of three; the remaining small difference, if any, is probably wiped out during the Ph.D. course, which can seldom be completed in less than four years even by a very brilliant student. Many universities encourage even their very good undergraduates to do their graduate work elsewhere, in contrast with the inbreeding tendency at British universities. This means that several months may be spent in moving a home and getting used to new conditions; but this is not the main reason why the course tends to be longer than in Britain. The American graduate student is usually forced to complete a relatively large number of lecture-courses and

examinations before he can even apply for permission to submit a thesis. Some of this work represents material that the British undergraduate would have covered in his last year ; but a considerable difference remains in practice, even when full allowance is made for this fact. Indeed this is one of the main differences in the 'conditions of work' of graduate students in the United States and Britain ; and it is arguable that the British tendency to leave the research student to plan his own attendances at lectures goes too far to the other extreme.

The differences in the arrangements for choosing graduate students, looking after their welfare, providing them with advisers, and for the refereeing and evaluation of their theses are not great and call for correspondingly little comment. The methods by which a scholar of distinction sets up and organizes a school of research workers have probably not greatly changed down the ages, since the main requirements of attracting recruits and of creating and maintaining a satisfactory personal relationship between the research director and the members of his team have always existed. The problems which it leads to, such as keeping temperamental people working happily together, avoiding bullying and yet seeing that everyone has a worth-while problem to work on, and seeing that everyone gets proper credit for his special contributions, are more difficult to-day, because of the increasing tendency to work in large teams, which is itself a result of modern trends in research. (Disaster occasionally results from too great an expansion of a flourishing team.) The other really striking difference in 'conditions of work' is a purely material one. The American graduate student in the physical sciences can confidently expect better offers than can his British cousin, once the 'period of apprenticeship' is completed ; but, during this period, he has a decidedly harder and rougher time. The newly qualified Ph.D. can expect several offers from industry in the region of 5,000–7,000 dollars, while a teaching post in a school, or a government post, might pay around 3,000–5,000 dollars, and a post-doctoral fellowship or junior instructorship would be worth about the same. (In purchasing power 4 dollars are roughly equivalent to £1.) As in Britain, there is considerable competition for the junior academic posts and post-doctoral fellowships ; but the number of industrial vacancies far exceeds the supply of men, and, since the Second World War, quite a number of firms have been forced into a quite new line of 'sales-talk' : 'Come and look at us and at the splendid laboratories and fine conditions of work we offer you'. All this may seem to compare very favourably with the £500–£700 which seems to be the market value of the newly qualified British Ph.D. Various other factors have also to be considered, such as the fact that Americans marry younger, the differing incidence of taxation and the existence of a National Health Service in Britain ; but, taken all together, they probably do not greatly change the overall picture. (The fear of a sudden illness and a large hospital bill is a very real one to many young American families, and numerous insurance schemes exist with the object of lessening this source of worry.)

The British graduate who wants to do research and can get himself accepted by a university at all can nearly always cover his living expenses and fees by means of scholarships or a government grant, without being specifically required to do any teaching or other work outside his research. Indeed, strict limits are usually set on the amount of teaching he may do, and other work is often forbidden altogether. This contrasts very strongly with the position of the American graduate student. There are, of course, innumerable endowed scholarships and loan funds ; but these are usually for quite small amounts, and roughly speaking, there are three ways by which a graduate student can hope to cover the main expenses of his research course. He may become a member of a team in his department that is working on some specific research project financed from outside, usually by the government. He may take a part-time job in the same way as an undergraduate student ; or, finally, he may be appointed a 'graduate assistant' by his department. This last type of post resembles the British one of student-demonstrator. A typical stipend would be 1,500 dollars, for which he is expected to give almost as much time to teaching as does a full member of the staff. This will usually consist mainly of laboratory demonstrating and the conducting of 'recitations' (that is, supervising examples classes held in conjunction with the lectures) but nearly always includes some formal lecturing. Add to this the fact that, as we have seen, he also has to pass various examinations and to pile up a fairly impressive record of attendance at advanced lectures as well as keeping himself informed on his own special field, and the wonder is that he has time for original thought at all. It is possible for a single man to live on his stipend ; but, if a graduate assistant is married and without private means, it is practically essential for the wife to take paid work. This she fully expects to do, and she will often earn more than her husband ! It is probably fair to say that the average American Ph.D. thesis contains more 'padding' and undigested material and fewer original ideas than does its British counterpart ; but it has almost certainly been produced under more difficult conditions.

It is not easy to compare the merits of the two systems. They are conditioned partly by the differences in the raw material that the colleges receive from the schools, which ultimately means that certain ground that is covered by undergraduates in Britain has to be left until the graduate student stage in America. Apart from this, any university that reduced its requirements for the Ph.D. degree to any great extent would lay itself open to the very damaging gibe of being a 'degree pedlar'. The fear of 'losing face' in this way is obviously a very real one, and makes any big change in standards difficult, even if it were desirable. I am fairly sure that I did not visit, or even hear of, any institution where a Ph.D. was obtainable without a great deal of hard work. One problem seems to be common to both systems, and in fact both systems handle it in a rather haphazard and piecemeal way, probably because no simple solution has ever been found. Although it may seem strange to say it, the problem is that of making the best use of the 'pure researcher', once he has qualified for his doctorate. How is he to be found an honourable and reasonably secure place in society, and at the same time prevented from becoming a crank or charlatan, or an inventor of impossible gadgets or a mere drone ? Many solutions to this problem have been tried in the past, such as private patronage of learning, monastic communities of various kinds, life-fellowships of colleges. Probably we are in the process of evolving a new arrangement on both sides of the Atlantic, something in keeping with the enormous expansion of research.

How does such a man fit into the American scene? He is probably good enough to be considered for a post-doctoral fellowship, but these seldom last for more than a few years. He may get congenial work as a member of a research group working in a university laboratory but financed by one of the big government agencies such as the Atomic Energy Commission, the Office of Naval Research or the National Science Foundation. The difficulty here is that funds are usually allocated annually and Congress can, and often does, impose cuts in the budgets of such agencies. Even apart from this, there is the fundamental difficulty that, before each year's money is handed out, there must have been a contact, somewhere along the line, between someone who understands just what the particular research project is all about and someone who does not but who may have power to reduce or withhold the next grant, or to divert the money to some other project. Much time and effort is obviously spent in trying to be fair about 'evaluating' reports on the work of the past year and also 'projects' for fresh research, which seems to be done mainly on the basis of referees' reports (I was asked to make a few myself); but it all produces a decided sense of insecurity for the people who are doing the work, knowing, as they do, that a grant may easily be cut next year for reasons totally unconnected with the merits of the work or its value to the community. Another possibility is an industrial or government post. Here, the short-term position is more secure; but most employers, quite understandably, expect a research department to perform a considerable amount of 'bread-and-butter work' which may be anything from routine testing to the development of a new plant on the pilot scale or the designing of circuits for a special requirement. Much depends here upon the director of the laboratory and on his ability to act as a buffer between his staff, who want to investigate interesting long-term problems, and his board, who naturally expect some visible return for the expenditure they are asked to approve. The final possibility is the traditional one of an academic post; but this is far from an ideal solution in present conditions. In these days of rapid expansion of demand for engineers, physicists and chemists the young instructor is likely to be faced with a heavy load of elementary teaching, and the fact that he has research ability does not necessarily mean that he has interest in, or aptitude for, pure teaching at an elementary level; nor does the fact that he is an expert at designing and using apparatus necessarily mean that he is capable of keeping a practical class running smoothly. If he has a young family, he is likely to find his stipend barely enough to live on, and he will be forced to take on yet more teaching during the 'summer sessions', or else to do other paid work during the three summer months. (I knew one young professor, in this position, who was selling copies of a famous encyclopædia as a sideline.) A few universities do have research professorships, while others will arrange that a distinguished scholar has a very light teaching load; but, with nearly all his time occupied, how can the young instructor hope to do the work that will gain him the reputation that would win him one of these coveted posts?

Be all this as it may, there can be no doubt that the 'lure of the ivory tower' is still immensely strong, and that one of the dearest wishes of many a bright student is to be asked to return to his university or college as a junior instructor. Anyone who doubts this must explain how it is that even quite small and obscure colleges seem to have little difficulty in filling their vacancies. Very little formal advertising is done, deans usually notifying one another of vacancies by means of circular letters. Contrast this with the fact that industrial firms who are in a position to offer better pay, probably coupled, as we have seen, with more time for research, are resorting more and more to publicity stunts in order to attract applicants. The explanation is probably two-fold. The scholar who has a real vocation for teaching and pride in training future leaders of men is, as he always has been, willing to work for less than his true market value and to face the drudgery of teaching large elementary classes. The scholar whose main ability lies in research feels sure that, in the long run, the universities will always be the real homes of fundamental research, and that, in due course, some of the very real difficulties outlined above will be sorted out. It does seem certain that the financing of research at the universities by outside bodies has come to stay, and that, in time, reasonable means will be evolved for regulating the inflow of money. The phrase 'going industrial' is often applied to a scientist who leaves academic life. It seems to convey not so much a feeling of superiority, but a subtle tinge of sorrow that one more good man has sold part of his soul.

A more disturbing point concerns the number of British physicists and chemists who are tempted, by the higher pay and lower taxation, to settle in the United States on a long-term basis. There is everything to be said for interchanges and visiting posts; but, in present conditions, it is hard to see how a prolonged stay can benefit either country in the long run.

OBITUARIES

Prof. Hermann Weyl, For.Mem.R.S.

Among all the mathematicians who began their working lives in the twentieth century, Hermann Weyl was the one who made major contributions in the greatest number of different fields. He alone could stand comparison with the last great universal mathematicians of the nineteenth century, Hilbert and Poincaré. So long as he was alive, he embodied a living contact between the main lines of advance in pure mathematics and in theoretical physics. Now he is dead, the contact is broken, and our hopes of comprehending the physical universe by a direct use of creative mathematical imagination are for the time being ended.

Weyl was fortunate in the manner of his death. On November 9, 1955, he celebrated his seventieth birthday, in full and robust health of body and mind. At the banquet which was given in his honour in Zurich, he received messages of goodwill and homage from all over the world. Less than a month later, on December 8, he walked out of his house to post a letter, suffered a heart-failure, and died instantly.

The beginning of Weyl's scientific life cannot be better described than in his own words. "I came to Göttingen as a country lad of eighteen, having chosen that university mainly because the director of my high school happened to be a cousin of Hilbert's and had given me a letter of recommendation to him. In the fullness of my innocence and ignorance I made

bold to take the course Hilbert had announced for that term, on the notion of number and the quadrature of the circle. Most of it went straight over my head. But the doors of a new world swung open for me, and I had not sat long at Hilbert's feet before the resolution formed itself in my young heart that I must by all means read and study whatever this man had written. And after the first year I went home with Hilbert's 'Zahlbericht' under my arm, and during the summer vacation I worked my way through it. These were the happiest months of my life, whose shine, across years burdened with our common share of doubt and failure, still comforts my soul." The words "read and study whatever this man had written" are the key to Weyl's breadth and versatility. Hilbert's method of work was to choose a field of mathematics, study it intensely for a few years, revolutionize it with a basic new idea, then drop it and look for another field. Weyl followed the same method, and was equally successful.

The following is a very incomplete chronological summary of Weyl's activity. Between 1908 and 1917 he worked on problems in classical pure mathematics, in particular the theory of numbers, singular integral equations, and functions of a complex variable. His book "Die Idee der Riemannschen Fläche" created a new branch of mathematics by uniting function-theory and geometry; the influence of this book led directly to a synoptic view of analysis, geometry and topology which has become a central theme in the mathematics of to-day. During 1917–23 he worked on the logical foundations of mathematics, and simultaneously took an active part in the development of Einstein's relativity theory and its generalizations. He discovered the first 'unified field theory' in which the Maxwell field appears along with the gravitational field as a geometrical property of space–time. This theory he soon rejected as being without empirical foundation; but it remains at least as plausible as any of the other unified theories which came later. Between 1923 and 1938 he created a general theory of matrix representations of continuous groups, which powerfully assisted the growth of quantum mechanics. He discovered that a large proportion of the regularities of quantum phenomena in atomic physics can be understood most simply by means of group theory. By bringing group theory into quantum mechanics he led the way to our modern style of thinking in physics. To-day the instinctive reaction of every theoretical physicist, confronted with an unexplained regularity in the behaviour of elementary particles, is to postulate an underlying symmetry-group.

After taking his degree at Göttingen, Weyl occupied chairs successively at the Federal Technical College in Zurich (1913–30), at Göttingen (1930–33), and at the Institute for Advanced Study in Princeton (1933–51). He was elected a foreign member of the Royal Society in 1936. He was twice married, and is survived by a widow and two sons.

Characteristic of Weyl was an æsthetic sense which dominated his thinking on all subjects. He once said to me, half joking, "My work always tried to unite the true with the beautiful; but when I had to choose one or the other, I usually chose the beautiful". This remark sums up his personality perfectly. It shows his profound faith in an ultimate harmony of Nature, in which the laws should inevitably express themselves in a mathematically beautiful form. It shows also his recognition of human frailty, and his humour, which always stopped him short of being pompous. His friends in Princeton will remember him as he was when I last saw him, at the Spring Dance of the Institute for Advanced Study last April: a big jovial man, enjoying himself splendidly, his cheerful face and his light step giving no hint of his sixty-nine years. Freeman J. Dyson

Prof. H. Oertel

Prof. Horst Oertel, who died on January 9 at the age of eighty-two, was formerly Strathcona professor of pathology in McGill University. Since leaving Canada in 1938, he had lived a retired life at his club in London.

Although born in Germany, near Dresden, Oertel received most of his education in the United States and took his medical degree at Yale in 1894. Shortly afterwards, he returned to Germany for postgraduate studies, first at Berlin, where he was much influenced by Virchow and Senator, and later, at Würzburg and Leipzig. His interest in philosophy, which continued throughout his life, was greatly strengthened by his contact with Wundt, whose reputation as an exponent of physiological psychology was then drawing students and research workers from many parts of the world.

Soon after his return to the United States in 1897, Oertel became the director of a department of pathology—later the Russell Sage Institute—that was then being developed in a large municipal hospital under the auspices of the New York University School of Medicine. In 1911, political changes in the city brought this association to an end, though Oertel maintained for some time longer his connexion with the Russell Sage Foundation. Much of his work at this time was upon nephritis, to the study of which he had been stimulated by Senator, and in 1910 he published a series of lectures on Bright's disease. It was this interest, too, that brought him to London in 1913 to work at Guy's Hospital—near Bright's own wards—on experimental nephritis and the embryology of the kidney. This "delightful and profitable departure", to use his own words, brought him into association with Laidlaw, Boycott, Keith and Assheton. In 1914, while still in London, Oertel received an invitation to an associate professorship at McGill University under J. G. Adami. Almost at once, he assumed full direction of the Department, for Adami left Montreal soon afterwards, first for war service and later to become vice-chancellor of the University of Liverpool.

At McGill, Oertel quickly developed an active pathological institute in close association with the Royal Victoria Hospital, and it was here that his most productive work was done. His previous experience in the United States, Germany and England had led him to a critical appraisal of the objectives of medical education at a time when the scope of the curriculum was being widened at an unprecedented rate. His tenure at McGill gave him the opportunity to put some of his views upon teaching into practice. These ideas soon gained a wider audience through the publication in 1921 of his "General Pathology", a book which was followed in 1927 by "Outlines of Pathology" and in 1938 by "Special Pathological Anatomy". All three bear the distinctive marks of Oertel's personality—his absorption with the historical development of pathology and its emergence as an independent biological science. Although addressed to undergraduates, their

scholarly character can only be properly appreciated by those of wider experience and fuller knowledge of the progressive emancipation of this medical science from its pragmatic origins.

The formative period of Oertel's life was at the time when many young graduates in the United States had come to realize the impact on medicine of the remarkable developments that had taken place during the later nineteenth century in Germany as a result of the mutual fertilization of the medical and fundamental biological sciences. Although to him a problem in pathology always appealed as a scientific inquiry that took origin from a wish for a better understanding of causal phenomena in disease, he showed none of that lack of appreciation, not unknown among medical scientists, of the humanitarian demands of medicine. But, like some of the more far-seeing of his contemporaries in his country of adoption, he came early to realize that natural philosophy does not necessarily lose its interest by possessing useful applications, and that efforts to solve the problems presented by disease are not necessarily without intellectual attraction. It was the effort to combine the searchings of the philosopher with the responsibility of the physician that distinguished Oertel's contributions to pathology.

G. Payling Wright

Mr. Sidney G. Starling

Sidney G. Starling died on December 16, at the age of eighty-two. He was born in Bradford and received his early education at the Grammar School and Technical College. Having obtained an exhibition and national scholarship, he entered the Royal College of Science, London, in 1891 under Prof. Rücker. Here he secured first-class honours, prizes and medals and worked as assistant and demonstrator during 1893–95. Working under C. V. Boys, he undertook the calculations required for the determination of the Newtonian constant of gravitation. Between 1895 and 1898 he was assistant lecturer in mathematics and physics at Battersea Polytechnic, during which time he graduated at the University of London and was awarded the Neil Arnott Exhibition and Medal. At the opening of the West Ham Technical Institute in 1898, he was appointed the first head of the Department of Physics and Mathematics, a post he held until his retirement in 1932. In 1899 he married Miss M. Briggs, who was an assistant in the Art Department at Battersea.

Throughout his lifetime, he was an active member of the Board of Studies in Physics in the University of London and a member of the Faculty of Science. In his earlier years he was an extensive abstractor of Continental papers for the Institution of Electrical Engineers and the Physical Society of London. In 1920 he was elected Fellow of the Institute of Physics.

Starling is probably most widely known as a writer of text-books of physics. The association of Duncan (the engineer) with Starling (the physicist) in the production of their "Text Book of Physics" (1918) was suggested by Sir Richard Gregory, of whom Starling was a great friend. Starling's own "Electricity and Magnetism for Advanced Students" (1912) has been a standard text-book throughout the years, appearing in many editions, the latest being revised in collaboration with A. J. Woodall in 1953. During his retirement there have appeared "Mechanical Properties of Matter" (1935), "Physics" (in collaboration with A. J. Woodall, 1950) and a revision of "Science in the Service of Man—Electricity" (in association with his son-in-law, H. J. Gray, 1949).

Staff and students respected Starling for his sympathetic understanding, scientific integrity and the quiet efficient way he solved technical and organization problems. There was not the slightest procrastination or duplication of effort. He was a strict disciplinarian and a stickler for punctuality. The ease with which he could erect apparatus for research or demonstration was particularly noteworthy. His published researches and writings do not convey his skill and versatility in this direction. In particular, he did pioneer work on aeroplane compasses (theoretical and experimental) at the time of the First World War.

All his hobbies were characterized by high achievement with apparently little exertion, ranging from shooting, golf and photography to silver smithing. From 1912 he had taken a very active part in Freemasonry. Only his closest friends will have appreciated his keen sense of humour, and even they can scarcely realize the many kindly acts of sympathy and encouragement he rendered to those in adversity. He is survived by a son and daughter.

William Swaine

Dr. George Slater

Dr. George Slater, one of the leading glaciologists of Great Britain, died at the age of eighty-one on January 27. He started his geological career when a schoolboy at St. John's College, York. Later, he continued as an amateur geologist while a schoolmaster at Haltwhistle, Northumberland (1895–97), and at Ipswich (1897–1918). He showed an early interest in palæontology, but at Ipswich, to quote Dr. F. A. Bather, he "became entangled with the complicated drifts of Suffolk". Patiently he mapped and recorded the structures seen in these disturbed drifts, in temporary sections, on successive faces in sand-pits and, during the First World War, in trenches dug for Army training. Though he published little during this early period, he became recognized as an authority on the glacial drifts of East Anglia, and in 1907 and 1911 led field excursions of the Geologists' Association at Ipswich.

He entered the Imperial College (Royal College of Science) in 1918 and remained a member of the geological staff until his retirement in 1939, having obtained the degree of D.Sc. (London) in 1926. The Geological Society awarded him the Murchison Fund in 1928, and in 1950 he received the Foulerton Award of the Geologists' Association.

Slater's research work was predominantly concerned with glaciology; and in 1921, when he accompanied the Oxford University Expedition to Spitsbergen as glaciologist, he was able to compare the structures seen in living glaciers with those that he had observed in the drift deposits of East Anglia. The results of his Spitsbergen work were published in the *Journal of Geology* (33, 408; 1925), and the next year he enunciated his ideas on "Glacial Tectonics as reflected in Disturbed Drift Deposits" (*Proc. Geol. Assoc.*, 37, 392; 1926). Between 1925 and 1932, at least fourteen papers dealing with various aspects of this theory were published. In them he described, often in meticulous detail, the structures seen in disturbed drifts and in glaciers. His theory that these drift structures were actually

formed within the ice-sheets, and now represent pseudomorphs of the original glacial structures, was not readily accepted by many workers when it was first proposed. In recent years, however, the hypothesis has been viewed in a much more favourable light. The evidence that he used to support his ideas was gathered from widely scattered sources: East Anglia, Wallasey, the Isle of Man, Møens Klint and Lønstrup (Denmark), Mud Buttes and Tit Hills (Alberta), drumlins near Toronto, the Rhône Glacier, and South Africa. Much of this material was collected for his D.Sc. thesis, but unfortunately his most remarkable work is, and probably will remain, unpublished. This is his detailed measured profile along the Cromer Cliffs, plotted on a scale of 1 in. to 100 ft. (1 : 1,200). The sections, mounted together to form a continuous strip many feet in length, are now housed in the Geological Survey Library.

Those of us who were privileged to know and work with George Slater will remember him for his kindness and the sympathetic assistance he was always prepared to give. He was a first-class instructor, especially to those who were taking geology for the first time, and many recognize the debt they owe him for his encouragement.

Gilbert Wilson

NEWS and VIEWS

Chemical Engineering at Manchester : Prof. F. Morton

The honours degree course in chemical engineering in the Department of Applied Chemistry of the College of Technology, Manchester, has been in existence since 1933, when the Chemical Engineering Section was started under Mr. W. Cowan, and since that time the Section has grown in importance both as an undergraduate and postgraduate school. With the recent expansion of the College the opportunity has been taken to raise it to the status of a separate Department of Chemical Engineering, and Prof. Frank Morton, at present professor of chemical engineering in the University of Birmingham, has been appointed to the newly created chair of chemical engineering in the University of Manchester and in the College. The Department will include fuel technology and metallurgy, and it is hoped later to include courses in nuclear engineering and corrosion engineering.

Prof. Morton graduated in applied chemistry from the Manchester College of Technology in 1930, and for a period was a member of the teaching staff of that Department, before entering industry in 1936 as research chemist to Trinidad Leaseholds, Ltd., of Trinidad. After being successively superintendent of research and development and chief chemist in the Company, he was appointed in 1948 to a readership in chemical engineering in the University of Birmingham, and in the following year became professor of chemical engineering there. Prof. Morton's research work has been concerned with the constitution of petroleum, with methods of separation of hydrocarbons, particularly in the middle-distillate boiling range, and with the mechanism of oxidation and combustion of hydrocarbons in a diesel engine. While at Birmingham he extended his investigations to the constituents of coal tar and, in particular, to a study of liquid–liquid extraction methods for the separation of tar acids and bases. He is a vice-president of the Institute of Petroleum and chairman of the Research Committee. In this latter connexion he has been concerned with co-operative research sponsored by the petroleum industry at a number of universities and with the work on the biological activity of petroleum sponsored jointly by the Institute of Petroleum and the Medical Research Council.

Linen Industry Research Association : Dr. A. J. Turner, C.B.E.

Dr. A. J. Turner, who is retiring from the post of director of research of the Linen Industry Research Association at the age of sixty-seven, has had a most distinguished career. A graduate of the Universities of London and Cambridge, his first research was done under Sir William Pope. Afterwards, working on aircraft and airship materials at the National Physical Laboratory, he was appointed in 1915 head of the Fabrics Research Section of the Royal Aircraft Factory (later Establishment). Immediately after the First World War, he became the first professor of textile technology in Manchester, holding this post until 1923, when he went to India to become director of research for the Indian Central Cotton Committee. Dr. Turner was personally largely responsible for the planning of the Committee's Bombay laboratories, and for the valuable technological reports which flowed from them in succeeding years. He returned to England to become head of the Spinning Department at the Shirley Institute, Manchester, in 1931, and remained there until he accepted in 1940 the post he is now vacating. During Dr. Turner's tenure of the directorship, the scope and volume of the work of the Linen Industry Research Association have increased enormously, and through his devoted service it has come to be accepted as the research centre of almost the whole linen industry and trade. As director, he has also represented the Association on numerous government committees. Dr. Turner's well-earned honours include the presidency of the Textile Institute (1952–54), an honorary associateship of the Manchester College of Technology (1951) and various offices of the Worshipful Company of Weavers; in 1950 he was appointed C.B.E.

Mr. D. A. Derrett-Smith

Mr. D. A. Derrett-Smith, who succeeds Dr. Turner, has been a member of staff of the Linen Industry Research Association since 1928, head of the Chemistry Department since 1938, and has had additional duties as deputy director for the past four years. He received his early training under Prof. G. T. Morgan at the City and Guilds Technical College, Finsbury, and afterwards graduated in The Queen's University, Belfast, with first-class honours in chemical technology. During his long period of service with the Linen Industry Research Association, he has made notable contributions to the chemistry of linen processing, which have been incorporated in the modern practice of bleaching, dyeing and finishing. Mr. Derrett-Smith is well known in textile circles, and will have the good wishes of all in his responsible new post.

Division of Fisheries and Oceanography, C.S.I.R.O., Australia : Dr. G. F. Humphrey

Dr. G. F. Humphrey has been appointed chief of Division of Fisheries and Oceanography of the Commonwealth Scientific and Industrial Research Organization, Australia, in succession to Dr. H. Thompson, who retired last year because of ill-health. The headquarters of the Division are at Cronulla, New South Wales. Dr. Humphrey is senior lecturer in the Department of Biochemistry, University of Sydney, having been a member of the University staff since 1941, and the bulk of his published research papers are on marine biochemistry, a field in which he has collaborated with the Division of Fisheries. His studies outside Australia have included work at the Molteno Institute, University of Cambridge, at the Universities of Glasgow and London, and at the marine laboratories at Plymouth, England, and Roscoff, France. It is intended to give increasing attention to the physical examination of the ocean as contrasted with the studies in marine biology, which have been the major concern of the Division of Fisheries in the past ; and to reflect this change in emphasis the Division has been renamed the Division of Fisheries and Oceanography. For the development of Australian fisheries more accurate and complete information is needed about the factors which lead to fluctuations in the abundance of fish in the surrounding seas ; this will involve the Division in more comprehensive studies of ocean currents, temperature distribution, salinity of the sea and its content of phosphate, and the influence of these physical factors on the reproduction, growth and distribution of fish populations.

Uranium for Peaceful Uses of Atomic Energy

Replying to questions in the House of Commons on February 28 regarding President Eisenhower's offer to supply uranium for developing the peaceful uses of atomic energy, the Prime Minister said that how this offer could best be utilized by the countries of the world, individually or in association, would need careful thought. A start had already been made in the Colombo Plan and in the Bagdad Pact as well as in bilateral arrangements between Great Britain and the United States and certain countries in Africa and Asia to help them in training in the peaceful uses of nuclear energy, and he thought that their first need would be to form a nucleus of trained technicians. British supplies of uranium, he added, are very limited, and he could not hold out hopes that we could follow the lead of the United States in that respect, although we have been working closely with the United States in such matters as technical help for countries which produce uranium. He agreed that it might be wise to consider channelling these supplies through the United Nations to all countries rather than through bilateral agreements.

Industrial Uses of Nuclear Energy in Britain

In replying to questions in the House of Commons on February 22 regarding the industrial uses of nuclear energy, the Lord Privy Seal, Mr. R. A. Butler, said that the Government intends to press ahead with this new source of power. For nuclear reactors which British firms might build in foreign and overseas territories, the Atomic Energy Authority is confident that natural uranium will be available as soon as it is required. Supplies of enriched uranium are limited and must be shared between defence and civil needs, but some of the civil share will be reserved for export. The output of enriched uranium is limited by the capacity of the Authority's diffusion plant at Capenhurst, and this is being watched with a view of meeting the needs of the nation. Mr. Butler also said that the Atomic Energy Authority will supply the necessary nuclear fuel, on a rental basis, for the reactor which Associated Electrical Industries proposes to construct. The terms for this loan, which are being very carefully watched, will cover the cost of fabricating the fuel elements ; a percentage of the total cost of the fuel, including an element for research and development ; the cost of fuels spent during the running of the reactor ; and the cost of reprocessing spent fuel elements. Associated Electrical Industries intends to make the reactor available for educational research work by a group of universities in south Britain ; but while paying tribute to the public spirit of this firm, Mr. Butler asked for notice of the further question as to what the firm is paying for the information and techniques supplied by the Atomic Energy Authority. He promised to consult the Lord President of the Council as to the best means of making full information on all these arrangements available to the House of Commons.

Technical Education in Britain

The promised White Paper on Technical Education (Cmd. 9703. H.M.S.O. 1*s.* 6*d.* net) includes a review of the position of technical education in England and Wales to-day against the background of the educational system as a whole, with a short account of the role of the universities, particularly in regard to technological education. The plan now announced proposes to raise the capacity of advanced courses at technical colleges as soon as possible from 9,500 to about 15,000, and to make increasing use of 'sandwich' courses for these advanced courses, backed by an adequate system of financial aid. Students proposing to attend courses leading to a technological award will be eligible for Technical State Scholarships, and the number will be raised as these courses develop, while the Government also proposes to allow ordinary State Scholarships awarded on the results of the General Certificate of Education examinations to be held not only for honours courses at universities but also for courses leading to a technological award. The Government also proposes to develop as many as possible of the twenty-four colleges at present receiving 75 per cent grant for some of their advanced work into colleges of advanced technology, with strong governing bodies and independence appropriate to the academic level of their work, and within the framework of a five-year programme of building development to cost £70 million, with a further £15 million for equipment over the period to 1960–61, inclusive, of which £39 million is to be started during the first three years. These colleges will be expected to develop their advanced work considerably and to divest themselves of work below the advanced level, as well as to undertake a substantial amount of research.

As regards technicians, five or six of whom may be required to every technologist, and craftsmen, while the Government is prepared to take its part in providing the additional facilities for technical education required to match any rise in numbers, industry must play the leading part in increasing the output of craftsmen. Besides adjustment of the terms of apprenticeship and education to suit changing needs, the Government looks to see the numbers of boys and

girls under eighteen released by employers for part-time day courses doubled; and, as industrial techniques develop, it will be for the technical colleges to provide short courses designed to explain the principles involved. The White Paper points out that it is in the national interest that more girls should be encouraged to study science or mathematics at the universities or training colleges and to take courses in technical colleges; but the Government gives no indication as to how the supply of teachers for the programme is to be found, beyond expressing the hope that industry will be ready to release yet more of its employees for part-time teaching during the day. The importance of adequate libraries in technical colleges and of co-operation between college, public and other libraries is also recognized.

The situation in Scotland is discussed separately. Here the great need is for better provision for local technical colleges run by education authorities, and the Government is ready to authorize a programme of building for technical education, to be started within the next five years, to the value of £10 million, with a further £2 million for equipment. A major increase in the recruitment of teachers will be required to man the new local technical colleges, and it is also pointed out that a further 15,000 students will be needed if Scotland is to attain proportionately even the same level of day-release students as in England to-day. As in England and Wales, much remains to be done to encourage girls with a practical or scientific bent to grasp the opportunities before them.

Notes on the United States, the U.S.S.R. and Western Europe are appended to the report, and also a report on 'sandwich' training and education from the National Advisory Council on Education for Industry and Commerce. Referring to the White Paper in the House of Commons on February 29, the Minister of Education said that the capital programme will be exempt from cuts, delays or postponements of any kind. Undue resources would not be devoted to one part of the education system, and he anticipated an early statement of the plans of the universities for the quinquennium 1957–62.

Design and Application of Small Digital Computers

The first Joint Computer Conference, sponsored by the Association for Computing Machinery, the American Institute of Electrical Engineers and the Institute of Radio Engineers, was held in December 1951 at Philadelphia, Penn., and consisted of a review of electronic and digital computers. This was followed in the two succeeding Decembers by conferences in New York and in Washington, D.C., where the problems of input–output equipment and of reliability, respectively, were discussed. Meanwhile, the Western Section of the Joint Computer Committee organized similar conferences during February 1953 and 1954 and a third during March 1955, but the only conference so far held by the Eastern Section was at Philadelphia, Pasadena, during December 8–10, 1954, the proceedings of which have now been published (pp. 92. New York: American Institute of Electrical Engineers, 1955; 3 dollars). The subject under discussion was the design and application of small digital computers, and the opening address, entitled "Small Computers in a Large World", was delivered by C. W. Adams (Massachusetts Institute of Technology), the conference chairman. Seventeen technical papers were presented, and in addition to the full texts of these papers and the discussions on them, the proceedings contains reports on three panel discussions on the following: small digital computers and business applications; redundancy checking for small digital computers; and small digital computers to assist large digital computers. Individual computers or systems dealt with include the National Cash Register Company's decimal computer (*CRC* 102-*D*), the Marchant MINIAC system, the TRADIC transistor digital computer, the Burroughs *E*101 computer, and the *IBM* 650 magnetic drum data-processing machine; many different forms and applications of magnetic drum storage are described. Of particular interest is the growing use of solid-state devices—transistors, magnetic cores and ferro-dielectrics—with their great potentialities for improved reliability, decreased power, space, heat and weight, and probably also increased capacity and decreased cost when they are utilized in quantity as components in digital computers.

Chemical Background of the Aluminium Industry

In connexion with the celebration of the centenary of the foundation of the aluminium industry by Henry Ste. Claire Deville, the Royal Institute of Chemistry has published a review entitled "The Chemical Background of the Aluminium Industry" (Monograph No. 3 of the Institute, 1955), prepared by Dr. T. G. Pearson, director of research of the British Aluminium Company. This monograph, which is a model of what such a publication should be, starts off with the raw material, no less than fourteen pages being devoted to bauxite itself. The purification of the mineral by the Bayer process is then considered, and this section provides an excellent summary of the underlying chemistry. Having now obtained the pure alumina, the smelting process is next considered, and this again is an admirable discussion. The refining of this product, for which a number of processes have been developed or suggested, completes the treatment of the normal production of the metal. Two short chapters dealing with the attempts which have been made to replace the Bayer process by the production of alumina of sufficient purity, on one hand, and by the Hall-Héroult electrolytic process on the other, both of which have their own fascinations, conclude the work.

Earthquakes during August 1955–January 1956

The two greatest earthquakes during August 1955–January 1956 attained magnitude 7¼, one being on January 10 in the Tonga Islands and the other on January 16 near the coast of Ecuador; the latter caused heavy property damage at Portoviejo and at Bahia de Caraquez. Six earthquakes attained magnitude 7¼. The greatest depth of focus of any earthquake during the period was 650 km. Earthquakes from this depth occurred on August 19 at Acre, Brazil, on October 21 and 30; on January 9 in the Fiji Islands region; on October 31 near the Tonga Islands; and on January 13 in the Samoa Islands. During the period two shocks were reported felt in Great Britain. That on August 22 was at Aberdovy, Merionethshire, and that on January 10 near Derby. Some sixteen shocks were felt in the European Alps, four in Turkey, two in Haute-Saône, France, and one in Spain; on January 12 an earthquake caused heavy casualties and minor damage to property in Hungary. On January 8 an earthquake at Guerrero in Mexico caused many injuries and heavy damage

to property at Acapulco, while on September 1 an earthquake in Costa Rica caused heavy damage in Toro Amarello, where ten people were killed and five hundred rendered homeless. On September 12 an earthquake of magnitude 6¼ from an epicentre at lat. 32·9° N., long. 29·8° E. occurred at 06h. 09m. 29s. G.M.T. and was felt over a wide area including Egypt, Palestine and Cyprus. In the region of the Nile Delta forty-five houses were wrecked and twelve schools collapsed. Twenty people are reported to have lost their lives as a result of this earthquake, including several children who died at Daher (Cairo) kindergarten girls school.

The Morphology of the Head of the Hawfinch

THE ability of the hawfinch, *Coccothraustes coccothraustes*, to crack open the stones of cherries, damsons and olives in order to feed on the kernels is generally well known; but the modifications which are present in the structure of the head and enable this comparatively small bird to perform such a feat have apparently received little attention. The method employed to crack open the fruit stones is noteworthy because each stone is held between the mandibles and is broken solely by the force applied by the jaw muscles; and no 'artifice', such as that employed by the thrush to smash snail shells, or the woodpecker to split almond stones, is used. The behaviour of the bird when feeding on fruit-stone kernels appears to follow a definite pattern. The bird usually selects fallen fruit, apparently discarding the soft parts. Observations and photographs by R. W. Sims, of the Department of Zoology, British Museum (Natural History) (*Bull. Brit. Mus.* (*Nat. Hist.*), **2**, No. 13; August 1955), show that a cherry stone is arranged in the mouth by the combined movements of the head and tongue until it is held lengthways between the mandibles at the back of the horny palate of the mouth with the suture of the stone lying in the median sagittal plane of the head. A quick snap of the jaw and the shell is neatly cracked along the suture or 'seam'. The halves of the shell are rejected and the kernel is swallowed whole, usually without being crushed. Experiments on breaking open cherry and olive stones show that pressures in the region of about 100 lb./sq. in. are required to perform this feat.

Schizaeaceae of the South of England in Early Tertiary Times

A BULLETIN of the British Museum (Natural History) by Marjorie E. J. Chandler, on the "Schizaeaceae of the South of England in Early Tertiary Times" (*Bull. Brit. Mus.* (*Nat. Hist.*), *Geol.*, **2**, No. 7; 1955. Pp. 24+6 pl.; 15*s.*), describes fertile specimens of three species of each of the Schizaeaceous genera *Anemia* (= *Aneimia*) and *Lygodium* from various freshwater clays of Eocene age from Hampshire and neighbouring counties. The specimens are small fragments of lignite extracted by washing. Previously the genera were known from the European Tertiary as a few ordinary compressions, but mostly without detail. The technique (which involved modifications of the usual maceration and microtoming methods) was partly due to the late W. N. Croft. The specimens are identified by matching with corresponding bits of recent leaves, and though the information is limited by the small size of the fragments, it extends to many points and is convincing. It is pointed out that the occurrence of these ferns (characteristic to-day of the wet tropics of the Old and New World) in southern England and preserved where they grew accords with the conclusions on climates reached from the Eocene seeds. Of perhaps greater significance is that, in this work, we have a study of Tertiary plants pressed, regardless of trouble, to what seems the ultimate extent and detail the material allows.

The Field Studies Council

AFTER twelve years of existence, when it was known as the Council for the Promotion of Field Studies, this well-known society issues its annual report for 1954–55 under its shorter and new name of the Field Studies Council. The report is again a record of considerable development and, except for one disquieting feature, indicates that the activities of the field centres at Dale Fort, Flatford Mill, Juniper Hall and Malham Tarn, as well as the bird observatory at Skokholm, are now accepted as an important part of the national provision for the teaching of natural history. Bookings this year have reached the highest figure, while the quality of work done continues to improve. The disquieting feature is that, despite the intense activity at the centres, the Council remains stretched to the limit of its financial resources. The appointment of more staff and the accumulation of a small sum as reserve are essential if work is to be properly planned and developed. During the year the centres were inspected by the Ministry of Education. It is to be hoped that when the full report of H.M. Inspectors is available the position of the Council will be considerably strengthened.

Scientific Problems of Humid Tropical Regions

THE study of tropical vegetation will form the subject of an international symposium to be held in Ceylon at the University of Colombo during March 19–21 under the sponsorship of the United Nations Educational, Scientific and Cultural Organization. The symposium will be attended by specialists from Belgium, Ceylon, Great Britain, India, Indonesia, Malaya, the Netherlands, Pakistan, the Philippines and the United States. Afterwards, during March 22–24, twelve scientific workers will hold a preparatory meeting on the subject of humid tropics research in order to examine specific activities for the near future. Among the projects proposed are the production of badly needed maps of humid tropical regions, the classification of vegetation within these regions, the organization of a zoological survey of Ceylon, and the organization of a Unesco-sponsored advisory committee for humid tropics research.

University of Leeds

THE following gifts have been made to the University of Leeds: £2,500 (under deed) to the Building Fund of the Chemistry and Physics Extension, from Boots Pure Drug Co., Ltd., Nottingham; £500 a year for two years to the Department of Inorganic and Structural Chemistry, from Tootal Broadhurst Lee Co., Ltd., Manchester, for research on nuclear magnetic resonance; £700 to the Department of Physical Chemistry, from BP Trading, Ltd., London, for research; and £3,500 to the Department of Coal Gas and Fuel Industries, from the British Coke Research Association, to support research on the disposal of effluents.

The following have been appointed to lectureships in the University: Dr. P. Grosberg (textile engineering) and Dr. E. V. Truter (textile chemistry).

"Quotation of Titles of Papers in Review Articles"

Dr. Kenneth M. Smith writes: "As one of the Editors of 'Advances in Virus Research' to which Mr. N. W. Pirie makes reference in his letter in *Nature* of March 3, may I make a brief comment? As I pointed out to Mr. Pirie at the time, the only reason we had reluctantly decided to omit full titles of papers in the bibliographies was the growing disinclination of authors to supply them".

Announcements

Dr. J. S. Weiner, honorary assistant director of the Medical Research Council Unit at Oxford on Climate and Working Efficiency, has been awarded the Vernon Prize for 1956 of the National Institute of Industrial Psychology. This Prize is awarded every second year to the investigator who, being a British subject and under the age of forty-five, has done, in the opinion of the Council of the Institute, the most valuable research work in the subject of industrial psychology or physiology.

The Hinchley Medal for 1955 of the British Association of Chemists has been awarded to Mr. T. McLachlan, vice-president of the Association and also president of the Association of Public Analysts. The Medal will be presented at 6 p.m. on March 16 in the Barnes Hall of the Royal Society of Medicine, 1 Wimpole Street, London, W.1, after which Mr. McLachlan will give an address on "The Analyst—Chemist, Technician or Magician?". Visitors will be welcome to the meeting. Further information can be obtained from the British Association of Chemists, Hinchley House, 14 Harley Street, London, W.1.

Prof. F. R. Winton, professor of pharmacology and dean of the Faculty of Medicine in University College, London, has been appointed the first visiting professor of pharmacology in the University of Sydney. The appointment has been made possible by the contributions to a special fund by pharmaceutical manufacturers in Australia whereby a guest professor of pharmacology will be invited to the University each year.

Miss N. M. Goodman has been appointed by the Medical Research Council to the Mapother Bequest Research Fellowship for the year 1956–57. The Fellowship is provided from a fund established by the late Mrs. B. M. A. Mapother for research in psychiatry, and is held by arrangement with the University of London at the Institute of Psychiatry, Maudsley Hospital, London.

When the Inorganic Nomenclature Commission of the International Union of Pure and Applied Chemistry met last July in Zurich to consider world-wide comment on the Tentative Rules for Inorganic Nomenclature, it was able to deal with about a third of the material before it. A further session will be held in Reading in April, when it is hoped to complete the work in order that a revised document may be available for publication well before the meetings of the Union next year in Paris.

To commemorate the centenary of the discovery of mauveine by W. H. Perkin, the Huddersfield Section of the Society of Dyers and Colourists is holding an exhibition in Room 65, New Extension, of the Huddersfield Technical College during March 8–11 (Sunday excluded). The exhibition consists of four sections: dyestuffs used before Perkin's time; the discovery of mauveine and the developments made from this discovery; the process of dyestuff manufacture; and the impact of colour on women's fashions throughout the world.

A one-week course on acoustics for aeronautical engineers will be held in the University of Southampton during April 15–21. Intended for engineers with no previous formal training in acoustics, the course will include the generation of aerodynamic noise and properties of sound waves; silencing methods and the effects of noise on people; electro-acoustic measuring techniques; and the effect of noise and vibration on aircraft structures. Further information can be obtained from D. M. A. Mercer, Physics Department, University, Southampton.

A conference on "Chromosomes" is to be held in the State Agricultural University at Wageningen, Holland, during April 16–19. The following will read papers, which will be afterwards discussed: Prof. E. Heitz, Prof. H. D. Springall, Prof. T. O. Caspersson, Mr. N. W. Pirie, Prof. A. Gustafsson, Prof. A. Müntzing and Prof. C. D. Darlington. Further information can be obtained from Prof. R. Prakken, State Agricultural University, Wageningen, Holland.

A conference on "Scientific Ability: its Detection and Development" will be held in the Anatomy Theatre, University College, London, on March 17. The speakers will include Prof. F. Grundy, Prof. N. F. Mott, Mr. Alec Rodger, Mr. M. A. Brimer, Prof. E. M. Delf Smith, Prof. R. M. Barrer, Mr. W. Llowarch and Mr. W. H. Dowdeswell. Further information can be obtained from the Secretary, British Social Biology Council, Tavistock House South, Tavistock Square, London, W.C.1.

The European Section of the Research Committee of the International Gerontological Association will meet in Basle during April 4–7, when the following topics will be discussed: ageing of cells and tissues; basic chemical and physical changes in ageing tissues; adaptation to changing conditions of life; autointoxication; resistance to infection; blood circulation (vascular) disorders in ageing; ageing of the central nervous system; nutrition and old age; genetic problems of ageing; and statistical treatment in research on old age. Further information can be obtained from Prof. F. Verzar, Institute of Physiology, University of Basle.

A one-day conference on "The Development of Sandwich Courses", dealing with the future organization of technical training for young men in British industry, has been arranged jointly by the Ministry of Education and the British Association for Commercial and Industrial Education and will be held in the Royal Festival Hall, South Bank, London, S.E.1, on March 22. 'Sandwich' courses consist of alternate periods, usually three to six months each, of theoretical education in a technical college and practical training in industry, and the course usually lasts for four or five years, leading in some cases to an honours degree or its equivalent; at the end of last year some fifteen hundred students in Britain were attending such courses in engineering and applied science. Between three and four hundred delegates, directors of training and similar officials, representing the major industries in Britain, are expected to attend the conference. Admission will be by ticket, applications for which should be made to Mrs. Kelly, Organizing Secretary, British Association for Commercial and Industrial Education, 8 Hill Street, London, W.1.

DETECTION OF SEED-BORNE PARASITES IN SEEDS

By Prof. A. E. MUSKETT and Dr. J. P. MALONE
Ministry of Agriculture for Northern Ireland

DETAILS of the Ulster 'Method' used for the routine examination of samples of flax seed for the presence of fungal seed-borne parasites were published in 1941[1], when the parasites mainly under consideration were *Polyspora lini* Laff., the cause of stem break and browning, and *Colletotrichum linicola* Pethybr. and Laff., the cause of seedling blight. Since then it has been shown[2] that this method can equally well be used for other seed-borne parasites of the flax crop, such as *Phoma* sp., the cause of foot rot, *Alternaria linicola* Groves and Skolko, the cause of *Alternaria* seedling blight, *Botrytis cinerea* Fr., the cause of grey mould, and *Fusarium lini* Bolley, the cause of wilt, as well as for the identification of moulds which may contaminate the seed. The method is extremely simple and consists of plating out the seeds on 2 per cent malt extract agar contained in Petri dishes, incubating the dishes at 22° C. for a period of five days and then examining the seeds for the production of colonies of the parasites. It is speedy and accurate, can be readily carried out by members of a laboratory staff trained in the elements of mycology and plant pathology, while the general technique fits in well with that used for seed purity and germination tests where it is necessary to deal with large numbers of seed samples as quickly as possible. The aim of the method is to determine with accuracy the percentage of seeds in any sample which are contaminated with the parasite in a viable condition.

In 1938 the details were published[3,4] of a laboratory method which had been devised for the routine examination of seed oat samples for contamination with *Helminthosporium avenae* Eidam, the cause of seedling blight and leaf spot in the oat crop. This method consists of plating out the seeds on damp filter paper contained in Petri dishes, submitting them to irradiation from a mercury vapour lamp, incubating at 22° C. and examining them after a period of eight days for the presence of conidia of *H. avenae* produced *in situ* on contaminated seeds. It has been used continuously since then for the examination of seed samples required for work with seed disinfection and in seed health survey investigations.

Although it has been found to be of great practical value, its general use has been handicapped by the fact that higher values for contamination are nearly always obtained when the seed samples have been stored in the laboratory for some time before examination. This has been shown to be due not to the spread of the parasite in any way from seed to seed during storage, but to the fact that the storage period conditions the fungus in some such way as to cause it to sporulate more freely. Whereas this method can be relied upon to provide accurate results for seed which has been stored for some time, it cannot be regarded as so reliable in the case of freshly harvested seed. This limitation proved to be a drawback to the use of the method for seed health survey work, and it was decided to see whether the use of the Ulster Method could be extended to cover the oat crop. As had been expected, the first results were discouraging, for in the case of some seed samples the heavy growth of moulds and bacteria rendered difficult the immediate recognition of colonies of *H. avenae*. Although it is the general practice in Northern Ireland to avoid, whenever possible, the pre-treatment of seed prior to testing in order that the results obtained may refer directly to the seed sample as received, yet this was obviously an instance demanding special consideration. The pre-treatment of seeds with a mild disinfectant such as a weak solution of chlorine has been frequently recommended for the purpose of surface sterilization[5–7], and, after further experimentation, it was found that with such pre-treatment—'Chloros' was used in this instance—much better results were obtained in the case of seed oats which were freshly harvested. It is believed that by using this modified technique an accurate assessment can now be made of the degree of contamination of an oat seed sample at any time from harvest onwards.

The Ulster Method, with this modification, has also given promising results for the determination of the degree of contamination of seed oat samples with species of *Fusarium*, the most commonly occurring of which are *F. avenaceum* (Fr.) Sacc., *F. graminearum* Schwabe, *F. nivale* Auct., *F. culmorum* (W.G.Sm.) Sacc., and *F. poae* (Peck) Wollenw. The results given for *F. nivale* have been of particular promise and it is probable that when minor difficulties, such as those which sometimes arise in distinguishing between *F. graminearum* and *F. culmorum*, have been overcome the method will be readily applicable for all species.

More recently the use of the Ulster Method has been extended to apply to the health examination of seeds of other crops, and both accurate and speedy results have been obtained in the following cases: *Phoma betae* Frank, the cause of black leg in sugar beet; *Fusarium* spp. as contaminants of the seeds of wheat and barley; *Helminthosporium sativum* Pamm., King and Bakke, the cause of foot rot of wheat and barley; *Alternaria brassicicola* (Schwein) Wiltshire, the cause of dark leaf spot of cabbage; and *Phoma lingam* (Fr.) Desm., the cause of canker of cabbage.

In all the work which has been carried out so far it has only been found necessary to apply a pre-treatment of the seed in the case of oats, when the occurrence of a copious growth of moulds is, in some cases, apt to make the identification of fungal pathogens more difficult. As already stated, any kind of pre-treatment is avoided wherever possible in order that the sample of seed may be tested as received. Where such treatment is found to be necessary, it is proposed to use the term 'Modified Ulster Method', leaving the term 'Ulster Method' to cover all those cases where no pre-treatment of the seed is applied.

With rising cultivation costs throughout the world, the need for using seeds and planting stocks of the best quality in order to obtain the highest possible yield and keep production costs as low as possible is very real[8]. For this reason it may be necessary in the future to pay more attention to seed health than has been given to this problem in the past, and the need of having techniques available for this purpose which are both speedy and accurate and capable of international acceptance is clearly of some importance. The use of such techniques will greatly facilitate the carrying out of seed health tests whether they be required for international trading,

internal trading within a country or for the carrying out of seed health surveys. That seed health surveys may yield results which are both of interest and importance has already been shown by that made for the health of flax seed produced in the United Kingdom. Although other techniques may be found to be more convenient in some instances, as, for example, in the case of blind seed disease of ryegrass caused by *Phialea temulenta* Prill. and Delacr.[8], yet the Ulster Method and the Modified Ulster Method would appear to have a wide application and are likely to prove of considerable value where the measurement of seed health is achieved by the direct examination of the seed for the presence of fungal pathogens.

[1] Muskett, A. E., and Malone, J. P., *Ann. App. Biol.*, **28**, 8 (1941).
[2] Muskett, A. E., and Colhoun, J., "Diseases of the Flax Plant" (W. and G. Baird, Belfast, 1947).
[3] Muskett, A. E., *Ann. Bot.*, N.S., **1**, 763 (1937).
[4] Muskett, A. E., *Ann. Bot.*, N.S., **2**, 699 (1938).
[5] Wilson, J. K., *Amer. J. Bot.*, **2**, 420 (1915).
[6] Noble, M., *Nature*, **168**, 534 (1951).
[7] Groves, J. W., and Skolko, A. J., *Canad. J. Res.*, **22**, 190 (1944).
[8] Muskett, A. E., *Trans. Brit. Mycol. Soc.*, **33**, 1 (1950).
[9] Muskett, A. E., *Trans. Brit. Mycol. Soc.*, **30**, 74 (1948).

DOCUMENTATION OF SCIENCE

IN place of the usual annual report, the International Council of Scientific Unions has this year arranged for its Abstracting Board to issue a paper by its secretary, Prof. G. A. Boutry, which was read at the International Congress on Documentation of Applied Chemistry, held in London during November 23–25. The paper describes this venture in international co-operation from its origin at an international conference on scientific abstracting which was held in Paris in June 1949, organized by the Department of Exact and Natural Sciences of the United Nations Educational, Scientific and Cultural Organization. Twenty-four countries were represented, and eight of the eleven scientific unions federated with the International Council of Scientific Unions. One of the recommendations in the Final Act emphasized the importance of establishing good co-operation between existing scientific abstracting services; another urged that all original articles appearing in scientific periodicals should include an author's abstract prepared according to an agreed set of rules; and a third recommendation proposed the establishment of a single *International Journal of Physics Abstracts*, preferably bilingual. As a result of these three recommendations, a joint commission was formed by the Council to discuss further this problem of co-operation in physics abstracting. The Commission first met in Paris on December 20, 1949, and it was at once realized that any practical measures involved the co-operation of those concerned with producing *Science Abstracts* and the *Bulletin Analytique du Centre National de la Recherche Scientifique*. A meeting between representatives of the joint commission and of these two abstracting journals was arranged in London in September 1950.

At this meeting it was agreed to urge all leading periodicals publishing original papers in physics to undertake to publish authors' summaries prepared according to rules set forth by the Royal Society and by the Unesco conference of 1949, and that these summaries, irrespective of the language in which the original papers were written, should be printed either in English or French. It was also agreed that some responsible international organization should ask the publishers of periodicals, whenever advisable, for special rates of subscriptions and, in addition, to ask the editors of important periodicals to send corrected page-proofs of their issues, or at least clippings of the synopses, to the offices of *Science Abstracts* and of the *Bulletin Analytique* at the time of going to press. Finally, the editors of these two abstracting periodicals agreed to co-operate and remain in close contact, and to speed up and increase the efficiency of their work, by whatever means they thought best; it was also agreed that some responsible permanent international organization should be able to help them if they needed such assistance. Accordingly, when the joint commission considered these proposals at its next meeting in July 1951, it decided to ask the International Council of Scientific Unions to dissolve the joint commission and constitute a Board for the International Abstracting Service, on which would be represented, besides the Council itself, the abstracting journals admitted as members (initially *Science Abstracts* and the *Bulletin Analytique*).

This suggestion was studied by Unesco and the International Council of Scientific Unions, and on May 16, 1952, it was agreed to establish such an Abstracting Board, maintained by funds originating from Unesco and the International Council and with the general secretary of the latter body as a permanent member. The Board formally began to operate on June 1, 1952, and its first general assembly met at Strasbourg in July 1953, when rules and by-laws were adopted and an executive committee appointed, the composition of which for 1953–56 is: *President*, Dr. P. Bourgeois; *Secretary*, Prof. G. A. Boutry; *Members*, Dr. E. Hutchisson, Prof. A. V. Hill and Prof. J. Wyart.

As a result of the Board's work, with the exception of a few publications printed in the United Kingdom, all periodicals containing original articles on physics and published in Australia, Belgium, Canada, France, Italy, the Netherlands, the United Kingdom and the United States have agreed to publish authors' summaries in English or French or both, written according to approved rules. Moreover, editorial co-operation has been so thorough that usually the member-journals print these summaries verbatim. Attempts to obtain the same co-operation in Scandinavian countries and in Germany continue, and the four main Japanese journals of physics have also been approached.

Fifty-five periodicals printed in the United Kingdom, the United States, the Netherlands, France, Germany, Italy, Sweden, Japan and the U.S.S.R. send to the Board or its associates, generally by air-mail, complete page-proofs, or, in a few cases, clippings of authors' summaries. In 1954 the Board arranged with the director of the Institute of Documentation of the U.S.S.R. Academy of Sciences to exchange proofs of six Russian and eight American periodicals for purposes of documentation, and this exchange started in February 1955. The proofs of the Russian periodicals are microfilmed in Paris and forwarded to the editors of the member-journals. The periodicals exchanged are as follows:

U.S.S.R.

Journal of Experimental and Theoretical Physics
Journal of Technical Physics
Communications of the U.S.S.R. Academy of Sciences
News of the U.S.S.R. Academy of Sciences
Progress in the Physical Sciences
Applied Mathematics and Mechanics

United States

American Journal of Physics
Journal of Chemical Physics
Journal of the Acoustical Society of America
Journal of Applied Physics
Physical Review
Journal of the Optical Society of America
Review of Scientific Instruments
Reviews of Modern Physics

The Board has also conducted an inquiry in twelve European countries as to the feasibility of a comprehensive Russian-to-English translating service in physics, and as an outcome of this inquiry the American Institute of Physics has announced the initiation, in November 1955, of a complete English translation of the Russian *Journal of Theoretical and Experimental Physics*.

Together with the Publication Committee of the International Union of Pure and Applied Physics, the Board has also promoted the publication of articles reviewing the work of the principal schools of research in physics in the U.S.S.R. and other Slavonic countries, and it is co-operating with the same body in the revision of the Universal Decimal Classification in physics. Steps have also been taken to facilitate the abstracting of non-periodical publications in physics.

As early as 1950 the Executive Committee of the International Council of Scientific Unions had expressed the opinion that the joint commission should be concerned with the abstracting of both chemical and physical literature, and this view was endorsed by the Council in October 1951, though later a proviso was added that work on chemical documentation should not be attempted before sufficient progress had been made in the field of physics. It was only in 1954, accordingly, that the Abstracting Board was ready to extend its activities into chemical literature, and this extension was authorized by the Council in October of that year. When notified of this decision, the International Union of Pure and Applied Chemistry, now represented on the Board by Dr. L. H. Lampitt, recommended *Chemical Abstracts* and the *Bulletin Analytique* as member-journals for chemical abstracting in English and French, respectively. These journals were unanimously elected to the Board and remain the only member-journals for chemistry. The editors of a number of important chemical periodicals have already been approached with the view of organizing the exchange of page-proofs. The International Union of Mechanics and the International Union of Biology have also expressed interest in the work of the Board, and Prof. Boutry concludes his paper with a warning that the time may be due when full-time salaried officials will be required for the work of the Board in place of honorary officials.

CONNECTIVE TISSUE AND ITS CHANGES WITH AGE

THE British Society for Research on Ageing held a meeting in the Littlewood Hall of the General Infirmary, Leeds, on January 20, under the chairmanship of Prof. R. E. Tunbridge, at which four papers were read and discussed. The first, by Dr. M. K. Keech, Dr. R. Reed and Miss M. J. Wood, dealt with the characterization of elastic tissue by means of the electron microscope. They presented evidence that the variable morphology shown by normal elastic tissue fibres from various sites indicates that elastin, the fibrous protein entity assumed to be present in all forms of elastic tissue, is a complex system, consisting of fibres coated with a dense, amorphous material. They also produced evidence that dermal collagen fibrils, either fresh or prepared substantially free from ground substance, when treated at 37° C. with alkaline buffer solutions of *p*H 8·8, or with periodate solution, *p*H 5·0, transform into structures closely resembling those in naturally occurring elastic tissue (see *Nature*, 176, 966; 1955; and *J. Gerontol.*, 10, 388; 1955). These structures stain like elastica and also are attacked by the enzyme elastase.

The so-called dense, moth-eaten fibres (*Ann. Rheumat. Dis.*, 14, 19; 1955), which result from the action of bacterial collagenase on collagen fibrils, also transform, when heated in water, to similar elastin-like structures (*J. Path. and Bact.*, in the press). The importance of these findings lies in the fact that the moth-eaten fibres are an index to the age of the collagen from which they arise. In the age range 0–20 years, collagen, when treated with collagenase, forms many such fibres. From collagen of ages 20–50 years, however, their number gradually decreases, while above the age of 50 none is produced. It is concluded, therefore, that the products of collagen breakdown become coated with a dense amorphous material to form the elastin-like structures. Apparently the coating material is present in young collagen, but gradually decreases in amount with age. Elastic fibres from ox ligamentum nuchæ, when treated with boiling 1 per cent acetic acid solution for 1 hr., are apparently devoid of collagen fibrils as judged by the electron microscope. Collagenase action, however, reveals that they still contain many short fibrils of degenerate collagen. In general, therefore, there are strong morphological grounds for believing that material resembling elastic tissue can originate from the breakdown of collagen.

In the second paper, Dr. P. F. Lloyd discussed some problems relating to the polysaccharide components of connective tissue, and dealt with these under three headings: the type of polysaccharide(s) present; the nature of the linkages binding polysaccharides to other components; and the function of the polysaccharides or polysaccharide-containing complexes. Knowledge of the first two is essential for a full understanding of the third, and all three need to be studied before the wider problems concerning the nature of the changes which occur in connective tissue on ageing can be seen in true perspective.

To facilitate work on connective tissue in general, and on elastic tissue in particular, paper ionophoretic and infra-red analytical methods have been developed. Paper ionophoresis on an apparatus fitted with 'Perspex' condensers above and below the paper appears to give excellent separations of mucopolysaccharides (potential gradient 18 V./cm.). It has been found that chondroitin sulphuric acid-A moves at a faster rate than chondroitin sulphuric acids-C and -B. The mobility of the latter polysaccharide is increased after treatment with testicular hyaluronidase. Extraction of ligamentum nuchæ with 5 per cent saline followed by fractionation leads to the isolation of chondroitin sulphuric acid-B and a hyaluronic acid, the nature of which has been demonstrated by chemical and physical methods. In addition, this elastic tissue contains probably chondroitin and also a new type of connective tissue polysaccharide which is either a sulphated hyaluronic acid or a sulphated polysaccharide containing both glucosamine and chondrosamine in approximately equal amounts.

Extraction with 10 per cent calcium chloride has led to the separation of an insoluble mucoprotein containing about 8 per cent polysaccharide. In its behaviour on treatment with elastase, it resembles elastin (0·5 per cent polysaccharide); and Dr. Lloyd expressed the opinion that it would serve as a con-

venient model for further enzymatic studies. The results of an examination of the action of pancreatic elastase on crude polysaccharide suggest that elastase is an oxidizing enzyme.

Dr. H. Saxl and Dr. G. N. Graham, in the third paper, gave details of an interesting histochemical and biochemical study of the Ehlers Danlos syndrome. The work has been carried out during the past five years on biopsy specimens from two patients suffering from this condition. One biopsy from each of these patients afforded the material for electron-microscope studies previously reported. Histological examination of a lesion from one of the patients (a boy aged 3½ years) showed an increased amount of elastic-staining material, paralleled by a decrease of collagen. The lesion was highly metachromatic and the periodic-acid – Schiff reaction was very positive. The elastic tissue from the lesion and that of the "apparently healthy skin" surrounding it was found to be resistant to elastase. Drs. Saxl and Graham directed attention to the fact that elastase can be inhibited by a component of normal serum. The elastase-inhibiting effect of the serum of Ehlers Danlos patients was found to be quantitatively increased over that of normal serum.

Although attempts to isolate the component or components of serum responsible for such inhibition of elastase by means of chromatography on an ion-exchange resin column have been made, the results so far obtained have been rather equivocal. However, there are indications that the inhibitory agent is a high-molecular-weight component associated with the globular serum proteins. Drs. Saxl and Graham have also made a study of the effect of the inhibitor using fresh ox ligamentum nuchæ as the elastic substrate and have found a loss of metachromasia if the enzyme, the substrate and the inhibitor are incubated together. There is, however, no loss of metachromasia if each of these components is permitted to act in turn on the ligamentum nuchæ. There is an increased susceptibility of elastic tissue to elastase in senile elastosis, and the elastic fibres of the human carotid artery and of the aorta are dissolved by elastase at a greater speed with advancing age. In the serum of patients belonging to the age-group in which there is a high incidence of arteriosclerosis, there is a reduced concentration of serum inhibitor for elastase which is related to a low concentration of the enzyme in the pancreas.

In vitro experiments have indicated that the inhibitor has a twofold biological action: first, the control of the enzyme elastase in the formation of degradation products; and secondly, the absorption of metachromatic mucoid and elastic-staining substances. From the work of Karczmar and S. M. Rose, who have shown that, in *vivo*, differential development can be correlated with inhibition, it would not seem too unlikely to suggest that the elastase inhibitor can be an essential factor in the formation of elastic fibre.

The final paper, by Dr. David Hall, dealt with the dependence of equilibria between connective tissue components on age. He said that the structural components of connective tissue are particularly resistant to metabolic reactions, but must be maintained at their normal concentration by the simultaneous presence of anabolic and catabolic enzyme systems and their appropriate inhibitors. Age changes in the susceptibility of the various structures to attack by their specific enzymes can be coupled with variations in concentration of those few enzyme systems which have as yet been identified. A full assessment of the equilibria between the various components can only be made when studies of tissue, enzyme and inhibitor from the same animal and from the same age-group are made. As a preliminary to these studies, it has been necessary to examine the chemical reactivity of the tissue components.

Alkali treatment of collagen results in the extraction of small quantities of protein under conditions which give marked production of elastin-like material when examined under the electron microscope. The protein is, in certain circumstances, rich in hydroxyproline and arginine, two amino-acids which one would expect to be extracted, if collagen were to change to elastin. In the case of young collagen, this hydroxyproline-rich material is extracted during the early period of treatment, whereas the extract from old collagen does not contain a high hydroxyproline content until longer periods of extraction have occurred.

Based on these results, and those stemming from the observations of the other workers in the group, it is possible to devise a hypothesis for a similar *in vivo* synthesis of elastin via collagen. If this is done, many of the hitherto unexplained questions concerning connective tissue can be solved: for example, the absence of an elastoblast, the variations in chemical composition of elastins of various age-groups, and the appearance of elastic staining materials which are really dissimilar, in senile elastosis and the Ehlers Danlos syndrome. It was stressed by Dr. Hall that this is only a hypothesis, but that it would act as a starting-point for the discussion of age relationships of collagen and elastin, by permitting them to be considered as a single unit rather than as two diverse structures which merely share a common site.

G. H. Bourne

NON-DESTRUCTIVE TESTING OF MATERIALS AND STRUCTURES

THE French and English editions of the report* on the symposium on "Non-Destructive Testing of Materials and Structures", held in Paris in January 1954 by the Réunion Internationale des Laboratoires d'Essais et de Recherches sur les Matériaux et les Constructions, include thirty-nine papers from fourteen countries, some of the discussion and a bibliography containing references to fifty-five papers on non-destructive testing. The symposium was very largely concerned with the testing of concrete, and the scope of the report is not therefore as extensive as the title suggests. There are, however, four papers in the report, by M. Mamillan, G. Dawance, A. Moles and J. Jacquesson, of France, which deal in particular with the testing of materials other than concrete, namely, stones, rock and soils.

The three sections of the report cover vibration methods (*A*), hardness methods (*B*) and radiographic methods of test (*C*), respectively. The numbers of papers dealing with these methods vary considerably: there are twenty-six papers in section *A*, nine in section *B* and four in section *C*. The papers are prefaced by short summaries introducing the sections

* International Union of Testing and Research Laboratories for Materials and Structures (RILEM). Proceedings of the International Symposium on Non-Destructive Testing of Materials and Structures. Vol. 1, pp. x+1–208; Vol. 2, pp. ii+209–404. (Paris: RILEM, 12 rue Brancion.) 2,000 fr.

of the report and a general note on research matters requiring further investigation, based on a report prepared by a working-group appointed during the symposium. The summary of section *A* contains a useful review in tabular form of types and applications of resonance and pulse velocity tests with their advantages and disadvantages. Like most of the papers, however, this summary is more concerned with laboratory tests than with field-tests, and an important omission in regard to the latter is mention of the practical difficulty of measuring path-lengths sufficiently accurately in testing cast in-situ concrete structures by the pulse velocity method. Some of the statements in the second table of this summary should also be interpreted with reserve, particularly the point that the variability of the quality of the concrete within a test specimen or structure can be obtained using the pulse velocity method. This has not yet been satisfactorily established: the variability of the pulse velocity may indicate the variability of the concrete in a structure, since a reduction of the pulse velocity usually indicates a reduction in strength, but relationships between pulse velocity and strength are not closely definable in the field.

The first six papers, from France, South Africa, Japan, United States and Italy, describe apparatus and techniques for measuring the elastic properties of concrete by resonance tests on laboratory specimens in longitudinal and transverse vibration. The paper by N. Stutterheim, J. P. A. Lochner and J. F. Burger (South Africa), including the results of corrosion studies on concrete and cement mortar, is of particular interest, while C. E. Kesler and Y. Higuchi (United States) also contribute a useful paper on experimental problems. The remaining seven papers on resonance tests, from Japan, France, Switzerland and Great Britain, consider the interpretation of test data. A topic common to the majority of these papers is the relationship between the elastic properties and the strength of concrete. The dynamic and static moduli of concrete are compared by J. P. Daxelhofer (Switzerland), R. H. Elvery (Great Britain) and A. Lazard (France), and further remarks on this matter are included by R. Cabarat (France), T. Takabayashi (Japan) and F. Arredi (Italy). Daxelhofer's contribution includes observations on the use of resonance tests in studying frost damage to concrete at the Lausanne Polytechnic.

The succeeding thirteen papers of section *A* are concerned with pulse velocity measurements and their interpretation. Relationships between pulse velocity and the strength of concrete are dealt with by R. Jones (Great Britain), J. Andersen and P. Nerenst (Denmark), Y. Kameda, K. Awaya and I. Yokoyama (Japan), G. Magnel and G. Huyghe (Belgium) and M. Okushima and Y. Kosaka (Japan), while some information on relationships for stones is given by M. Mamillan. Jones's paper is noteworthy as a summary of much basic research at the Road Research Laboratory, Harmondsworth, and Andersen and Nerenst give a detailed account of their experience using the condenser chronograph developed at the State Testing Laboratory, Copenhagen. These two papers and those by Kameda, Awaya and Yokoyama, by A. Voellmy (Switzerland) and by Magnel and Huyghe, will probably be the papers of most interest to readers concerned with field-work on concrete, and a paper by G. Dawance to readers concerned with field-measurements on rocks. A section in the paper by J. Chefdeville (France) on the detection of faults and cracks supplements Jones's remarks on this subject, and the detection of fire damage is considered by Andersen and Nerenst and in the joint paper by Kameda and his colleagues.

In section *B*, on hardness testing, papers are contributed from Yugoslavia, Germany, Switzerland, Brazil and France, in which countries hardness tests on concrete have received greatest attention. K. Gaede (Germany) and E. Schmidt (Switzerland), prominent workers in this field, present papers describing the use of the Franck, Einbeck and Schmidt hammers, while G. Weil (Germany) points out that the Franck hammer is favoured in Stuttgart. Papers by G. Dawance and D. Jetvic, R. Peltier and P. Meynier describe experience of the use of the Schmidt hammer in France, and P. Vassitch (Yugoslavia) discusses general problems associated with hardness tests and considers both indentation and rebound measurements. A. Voellmy compares results obtained using different types of hammer and by penetration tests, and implies that the Schmidt hammer is preferable to other types. This point is clearly a matter of controversy among workers with experience of hardness testing, however.

The four papers of section *C* describe radiographic testing techniques that are still in their infancy. With one exception—a short note by G. Huyghe (Belgium)—they deal with research in France. J. Brochard describes and discusses density measurements by gamma-radiation at the Centre Expérimentale de Recherches et d'Études du Bâtiment et des Travaux Publics and the measurement of water content by neutron bombardment. J. P. Fackler's paper is a detailed account of gamma-ray tests on concrete at the Centre Scientifique et Technique du Bâtiment for the specialist, and J. Jacquesson's paper considers a problem in the technique of measuring soil densities.

The report is a useful and informative account of progress and investigations prior to 1954. It appears that it was decided to omit some of the discussion in the report, presumably in view of the large number of papers. Presentation of a large number of papers during the symposium had the effect of reducing the time spent on discussing the difficulties attending application of the methods of test and the practical significance of field-test results obtained by them. These matters are vitally important, and determine the value and promise of existing techniques of non-destructive testing in regard to concrete construction.

A. E. SEDDON

TEXTILE INDUSTRIES IN THE UNIVERSITY OF LEEDS

REPORT FOR 1953–54

THE eightieth report, to the Worshipful Company of Clothworkers of the City of London, of the Advisory Committee of the Departments of Textile Industries and Colour Chemistry and Dyeing, University of Leeds*, covering the session 1953–54, notes that the new building to house the man-made fibres division of the Department was rapidly approaching

* Report to the Worshipful Company of Clothworkers of the City of London of the Advisory Committee on the Departments of Textile Industries and Colour Chemistry and Dyeing in the University of Leeds, for the Session 1953–54. Pp. 42. (Leeds: The University, 1955.)

completion. A third chair, that of textile technology, has now been instituted in the Department, and the research school in the Department of Colour Chemistry and Dyeing has been further strengthened by the appointment of an Imperial Chemical Industries, Ltd., Research Fellow. The graduates of both Departments are in keen demand by many branches of industry. In textile physics further work has been carried out on the examination of fibre surfaces by replica methods, and a study of the fine structure of keratin fibres disintegrated by various techniques has shown that super-contraction is molecular rather than fibrillar in origin. A study has been made of the pigment granules isolated from various wools and hairs, and of their location in the fibres. In textile chemistry good progress is reported in the synthesis of polypeptides and related compounds, and in the search for new cross-linking agents it was found that reductone undergoes a unique type of polymerization in aqueous solution and that the polymer so formed is deposited inside the fibres. Further work was carried out on the initiation of the polymerization of vinyl compounds inside wool fibres with persulphates, on the formation of polyacrylonitrile in wool and on suint and wool wax; a strikingly novel approach has been developed to the problem of dimensional stability, and a mixture of fluorescent dyes has been devised which gives different colours with wool, cellulosic fibres, cellulose acetate, nylon, 'Terylene' and 'Orlon'. In textile engineering, work continued on the development of the new type of cap designed to give uniform spinning tension, on the drying of wet fibrous materials and theoretical studies on the use of felts in removing water in the manufacture of paper. In textile technology the electronic mule was being used with great success for studying the behaviour of fibres during the drafting of condensed slivers, and a comprehensive investigation was in progress on the effects of weaving tensions on cloth characteristics with special reference to rayon fabrics. Changes occurring in the setting of nylon were being studied, and further progress has been made in work on the proofing of viscose rayon against bacterial attack.

The Department of Colour Chemistry and Dyeing made further progress in its studies of the basic reactions of anthraquinone chemistry, completing the direct hydroxylation of *peri*-naphthalimide and the quinoxaline derived from acenaphthenequinone, and pyranthrone, *amphi-iso*pyranthrone, and 6-phenyl-*meso*benzanthrone. Other work has related to the mode of formation of the anthraquinone carbazole dyes from derivatives of 1 : 1′-dianthraquinonylamine, the reactions involved in the reconversion of sulphuric esters of reduced forms of vat dyes into the parent compounds, and on the nature of the products formed by the 'over-reduction' of indanthrone. Work on the action of Grignard reagents and dialkylcadmiums on alkylquinolinium salts was completed, and a relation found between the basic strength of anions and their orientation in nuclear substitution reactions. Work on the properties of the N-methyl-derivatives of anthraquinone–acridine dyes, the chemistry and dyeing properties of hæmatin, the colouring matter of logwood, and quantitative studies on the dyeing characteristics of chlorinated wool continued, while the dyeing of blends of wool and 'Fibrolane', and the dyeing characteristics of wool–nylon, wool–'Ardil' and nylon–'Ardil' for mixtures of acid and pre-metallized acid dyes were also investigated. Lists of publications are included.

HIGH-ENERGY PARTICLE ACCELERATORS IN THE UNITED STATES

ONE of the most noteworthy features of the International Conference on the Peaceful Uses of Atomic Energy held in Geneva last August was the series of evening lectures delivered by distinguished scientists. In particular, Prof. E. O. Lawrence's talk on August 11, in which he outlined the research programme in the United States concerned with the production of large currents of high-energy sub-atomic particles by means of accelerators, was especially interesting and provoked much discussion. The illustrated article, "High-Current Accelerators", which is contributed by Prof. Lawrence to the December 9 issue of *Science* (**122**, 1127; 1955), is based on his talk to the Geneva conference, and in it he emphasizes the importance of the problem of the production of intense beams of high-energy particles for future progress in nuclear physics. This is illustrated by the remark that the particle current has steadily decreased as the energy has increased—milliamperes for the 1940 cyclotron, microamperes for the 1943 synchrocyclotron, millimicroamperes for the present cosmotron and bevatron—and that, extrapolating on this basis, currents of only two protons per hour will be produced by accelerators giving particles of 10^{10} eV. energy. Reference is made to the work of L. H. Thomas and to the later approaches of V. Veksler and E. M. McMillan to the problem of a suitable magnetic field for a high-energy cyclotron. The basic similarity between the solutions in providing an azimuthal variation in the magnetic field to achieve focusing of the particles is pointed out.

Prof. Lawrence then describes briefly experiments that have been carried out in the Radiation Laboratory of the University of California, Berkeley, where he is director, with an electron model of a clover-leaf (this refers to the shape of the magnet pole-pieces) cyclotron. The model operated in complete agreement with theoretical expectations and showed that the Thomas-type field can provide the necessary axial and radial stability and that the accelerated electrons can stay in phase with the constant-frequency accelerating voltage. In addition to producing high currents of high-energy particles, equivalent to 300-MeV. deuterons, with very low voltages on the accelerating electrodes the clover-leaf cyclotron possessed the admirable property of easy extraction of the beam. Mention is also made of recent novel approaches that have been suggested to the problem of adapting cyclotrons and betatrons to produce high currents of high-energy particles, and these are now being put to practical test by the accelerator design group of the Mid-western Universities Research Association under the direction of Prof. D. W. Kerst.

During the past four or five years, along with the development of the clover-leaf cyclotron, the Radiation Laboratory has concentrated much effort, in collaboration with the California Research and Development Co., on the construction of a linear accelerator of the cavity-resonator type devised by L. W. Alvarez. The objective is to produce a particle accelerator capable of delivering thousands of kilowatts of high-energy protons. Details are given by Prof. Lawrence in his article of this *A*-48 linear accelerator, including the ion-injector, the beam focusing and steering magnet, the 24-Mc./s. buncher

and quarter-wave accelerator already completed, and the two 48-Mc./s. resonant-cavity accelerator sections, each 20 ft. long, which are still under construction. The injector consists of an arc source, in a solenoidal magnetic field, mounted on insulators in a vacuum envelope, and a focused ion beam of up to ¾ amp. has been obtained. Deuterons are accelerated by the quarter-wave machine from 140 keV. to about 1 MeV., at which speed they enter the two resonator-cavity sections. It is hoped finally to obtain an output from the complete accelerator of ¼ amp. of 7·8 MeV. deuterons, and it is expected that the accelerator will be in operation early this year.

EFFECT OF UREA ON TRYPSIN AND ALPHA-CHYMOTRYPSIN

By Dr. J. IEUAN HARRIS*

Carlsberg Laboratorium, Copenhagen

MANY simple organic substances such as urea are known to modify the specific stereochemical configuration of protein molecules in aqueous solution, and it is now well established that the increase in intrinsic viscosity encountered when native globular proteins are dissolved in concentrated urea solutions may be interpreted in terms of an increased molecular asymmetry associated with the unfolding of polypeptide chains from their specific 'native' configurations[1]. Viscosity measurements carried out in urea solutions have thus been frequently used as an experimental index of protein denaturation[1]. A more complete characterization of such a complex and ill-defined phenomenon is, however, obtained when viscosity changes are correlated with changes in other and entirely different properties of the protein molecule measured in the same chemical environment[2]. Although such an opportunity presents itself in the case of the biologically active proteins, a survey of the literature dealing with the effect of urea on a number of proteolytic enzymes reveals that in many instances the measurement of enzymatic activity has been used as the sole criterion of denaturation[3–7].

The assumption that protein denaturation and enzymic activity are mutually exclusive phenomena can be valid only if activity measurements are carried out under conditions which are not in themselves conducive to denaturation or to a reversal of a previously established denaturation effect, and although this crucial condition was stated by Anson and Mirsky[8] in their classical studies on the reversible denaturation of proteins, it has not always received the attention that it deserves. Thus in some cases the effect of urea on an enzyme has been evaluated on the basis of activity measurements carried out by the addition of an aqueous solution of the enzyme to a substrate dissolved in urea[3,8], and in others, urea solutions of an enzyme have been assayed under conditions which involve a dilution of the urea concentration in the assay medium[3–7]. These experimental procedures frequently lead to equivocal conclusions, since the possibilities that the 'active centre' of an enzyme molecule may be shielded from urea denaturation by formation of a stabilized enzyme/substrate complex, or that an inactivated denatured molecule may be subject to reversible reactivation, are not taken into consideration.

The crucial importance of relating changes in enzymic activity to changes in one or more of the physical properties of the enzyme protein measured in the same chemical environment received further emphasis when it was shown in this laboratory[2] that urea-denatured ribonuclease retains the catalytic functions of the native enzyme. Alternative explanations therefore become possible for the results obtained in previous studies on the action of urea on chymotrypsin[3], papain[4], pepsin[5], catalase[6] and trypsin[7]. For example, in a recent communication, Viswanatha and Liener[7] report that trypsin forms a stable active system in the presence of 8·3 *M* urea at *p*H 7·6; in an endeavour to explain this apparent retention of activity, it was postulated that the native active trypsin molecule is prevented from unfolding by formation of a stable protein/urea complex. The alternative possibilities, that the enzyme retains activity in an unfolded form, or that it is reversibly unfolded in 8·3 *M* urea, are not considered, despite the fact that activity was always measured under conditions which involved a five-fold dilution of the urea concentration. In view of such considerations, the effect of urea on the enzymic activities of trypsin and α-chymotrypsin has been re-investigated.

Freshly prepared 1 per cent solutions of a dialysed, recrystallized preparation of trypsin (obtained through the courtesy of the Novo Terapeutisk Laboratorium) in the appropriate concentrations of urea (A.R. grade, recrystallized from aqueous ethanol before use, and dissolved in glass-distilled water containing 0·1 *M* potassium chloride) at *p*H 4·0, were subjected to viscosity studies in a capillary viscometer maintained at 20° (± 0·01) C. Aliquot portions of the same freshly prepared solutions were diluted twenty times with the corresponding urea solution and assayed[10] against α,N-toluenesulphonyl-L-arginine methyl ester (0·005 *M*) (*a*) in the appropriate concentration of urea, and (*b*) in aqueous solution, at *p*H 7·8 and 25°. Activities expressed as zero-order velocity constants were calculated from the initial slopes of alkali uptake curves automatically recorded by means of a Jacobsen–Léonis *p*H-stat[11]; for purposes of comparison the activity of a control aqueous trypsin solution (1·72 m*M*/min./mgm. trypsin nitrogen) is expressed as 1. The results obtained are summarized in Fig. 1.

The intrinsic viscosity of trypsin increases as a function of the concentration of urea and approaches a maximum value in 8 *M* urea; and a corresponding decrease in enzymic activity is observed when assays are carried out in the presence of the appropriate concentrations of urea. Thus, contrary to previous results[7], trypsin is not active in 8 *M* urea; and furthermore, an aqueous solution of trypsin is rapidly inactivated (75 per cent inactivation during 2 min.) in 8 *M* urea at *p*H 7·8 even in the presence of α,N-toluenesulphonyl-L-arginine methyl ester. In 4 *M* urea, where the viscosity increase is 55 per cent of the maximal, trypsin retains 48 per cent of its initial activity, and similar correlations between increase in viscosity and loss of activity are observed at other concentrations of urea. When assayed in aqueous solution, however, urea solutions of the enzyme are found to regain full activity (Fig. 1).

These results suggest that at each concentration of urea a mobile equilibrium exists between native active trypsin and unfolded inactive trypsin (cf. refs. 12 and 13); equilibrium is rapidly attained at 20° and *p*H 4, is independent of trypsin concentra-

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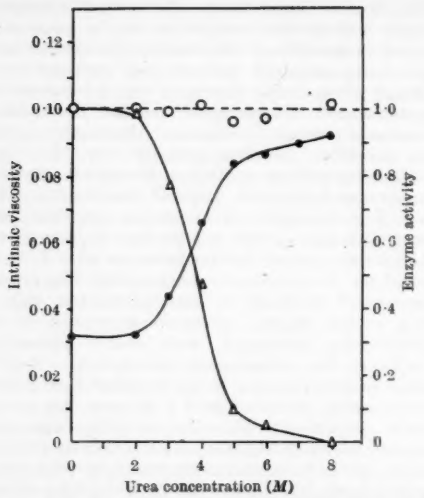

Fig. 1. Effect of urea on trypsin. ●, Intrinsic viscosity (gm./100 ml.)$^{-1}$, 1 per cent trypsin in urea *p*H 4, 20°. Esterase activity (α,N-toluenesulphonyl-L-arginine methyl ester, 0·005 *M*) *p*H 7·8, 25°: △ in urea; ○ in aqueous solution (1·72 m*M*/min./mgm. enzyme nitrogen = 1·0)

tion, and is completely reversible on dilution. In 8 *M* urea, trypsin exists entirely in a stable, unfolded inactive form which regains its former active configuration in aqueous solution. At intermediate concentrations of urea, however, the initially formed reversible equilibrium states are subject to a secondary, irreversible inactivation process which is maximal in 4 *M* urea where, according to the equilibrium hypothesis, the solution contains equimolar concentrations of active enzyme and of potential substrate in the form of unfolded enzyme molecules. Furthermore, although the composition of the equilibrium mixture is independent of the initial trypsin concentration, the kinetics of the subsequent inactivation reaction suggest that it is an enzyme-catalysed reaction which depends on residual trypsin concentration, *p*H and temperature (Harris and Linderstrøm-Lang, to be published). No increase in non-protein nitrogen could be detected (as measured by ultra-violet absorption at 280 mμ of fractions soluble in 10 per cent trichloracetic acid) in 4 *M* urea, but preliminary end-group studies are nevertheless consistent with the view that inactivation is due to a limited enzyme-catalysed autolysis at *p*H 4. Similar explanations have been proposed[12,13] to account for the irreversible inactivation of trypsin in neutral and alkaline aqueous solutions, and for the enhanced autolysis of trypsin in 4 *M* urea at *p*H 7·6[7].

In the case of α-chymotrypsin (recrystallized, salt-free preparation), viscosity studies were carried out on 1 per cent solutions at *p*H 5·0 and 20°, and enzyme activities were determined by the esterase procedure[10] (L-tyrosine ethyl ester, 0·02 *M*, *p*H 7·8, 25°). Results are summarized in Fig. 2. The viscosity of chymotrypsin increases sharply as a function of urea concentration, and the close correlation between increase in viscosity and loss of enzyme activity suggests that α-chymotrypsin also forms equilibrium mixtures of native active molecules and unfolded inactive molecules in urea solutions.

At *p*H 5 and 20° equilibrium is attained very rapidly; but in contrast to trypsin the extent of unfolding is markedly influenced by *p*H. Thus in 4 *M* urea at *p*H 5·0, chymotrypsin appears to exist entirely in the native state and retains full activity when assayed in the presence of 4 *M* urea at *p*H 7·8. At *p*H 4·0, on the other hand, an equilibrium mixture is formed which contains about 30 per cent of unfolded inactive molecules and the extent of unfolding increases further as the *p*H is lowered. In addition, the equilibrium which is rapidly established in urea solutions at *p*H 5 and 20° is not reversed to any appreciable extent in the presence of substrate in aqueous solution at *p*H 7·8 and 25°, that is, under conditions which lead to quantitative recovery of activity in the case of trypsin. Equilibrium mixtures of chymotrypsin are also subject to a secondary, irreversible enzyme-catalysed inactivation reaction; for example, although chymotrypsin is initially 80 per cent active in 5 *M* urea, the activity is reduced to 40 per cent on standing for 30 min. at *p*H 5·0 and 20°.

From the results of this investigation, it may be concluded that, unlike ribonuclease[2], trypsin and chymotrypsin do not retain activity in an unfolded form, and that covalent cross-linkages are in themselves not sufficient to maintain the integrity of the specific geometrical configurations which are essential for catalytic activity. Nevertheless, for practical purposes it is possible to take advantage of the fact that both enzymes are stabilized to a considerable extent against urea inactivation in the presence of a substrate, and can thus be used to degrade proteins which are themselves susceptible to denaturation in urea but which resist digestion in their native configurations[14,15]. The well-known hæmoglobin assay procedures for both trypsin[16] and chymotrypsin[3] are in fact based on this principle, while, more recently, similar considerations were found to apply in the case of carboxypeptidase[17].

I wish to thank Prof. K. Linderstrøm-Lang and Dr. M. Ottesen for their stimulating interest, helpful suggestions, and generous hospitality, and Dr. W. F.

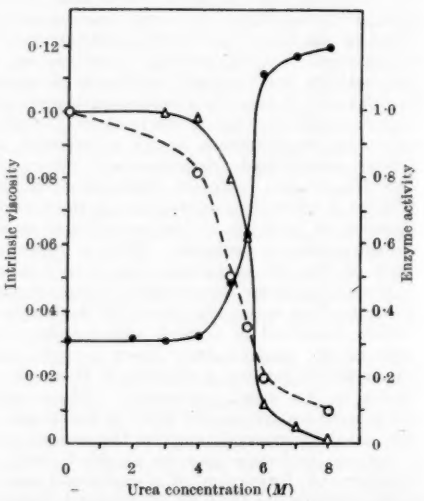

Fig. 2. Effect of urea on α-chymotrypsin. ●, Intrinsic viscosity (gm./100 ml.)$^{-1}$, 1 per cent chymotrypsin in urea *p*H 5·0, 20°. Esterase activity (L-tyrosine ethyl ester, 0·02 per cent) *p*H 7·8, 25°: △ in urea; ○ in aqueous solution (0·045 m*M*/min./mgm. chymotrypsin nitrogen = 1·0)

Harrington for advice in the procedures and interpretation of viscometry. [Jan. 12

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STRUCTURE OF SMALL VIRUSES

IT is a striking fact that almost all small viruses are either rods or spheres. The purpose of this article is to explain this observation by means of the following simple hypothesis: a small virus contains identical sub-units, packed together in a regular manner. It has been suggested before[1] that viruses are constructed from sub-units; but the idea has not previously been described in precise terms or put forward as a general feature of all small viruses.

We believe that there is conclusive evidence for this hypothesis in two cases and suggestive evidence in a number of others. As most of the present evidence comes from the plant viruses, we shall restrict our discussion to these, except for a few remarks on animal viruses at the end of the article.

Plant Viruses

Notice first that all plant viruses which have been studied carefully are extremely regular in their shape and size[2]. In electron micrographs their dimensions are constant. One particle of turnip yellow mosaic virus, for example, is the same size as another, to within the errors of measurement. Moreover, the 'spherical' viruses have shapes very close to that of a sphere—there seem to be no ellipsoidal plant viruses. All cases where they have appeared as flattened spheres have been shown to be due to the surface tension caused by drying prior to electron microscope examination. In good photographs there are sometimes suggestions that the 'spheres' are more nearly regular polyhedra, which, as we shall see, is what one might expect.

The great regularity of plant viruses is shown even more strikingly by their ability to form crystals (or paracrystals) which give good X-ray photographs[3], often with reflexions extending to small spacings. From this we can infer that a very high degree of order exists within such viruses, and that, to a resolution almost at the atomic level, one virus particle appears identical, or at least very similar, to all its sister virus particles. A plant virus can thus be considered a 'molecule' in the sense used by protein crystallographers—an entity, the major part of which has its atoms arranged in definite (relative) positions in space.

All known plant viruses consist of two chemical components only: protein and ribonucleic acid. It seems likely that there is a general plan for their relative positions and that the majority of the protein lies on the outside of the virus, surrounding a central core composed largely, if not entirely, of ribonucleic acid. This arrangement is well established for only two viruses—the spherically shaped turnip yellow mosaic virus (by Markham[4]) and the rod-shaped tobacco mosaic virus (by both the Tubingen[5] and Berkeley groups[6])—but we believe that it is likely to apply to all simple viruses. That is, the protein component of a round virus is a spherical shell, and of a rod-shaped virus, a cylindrical shell. Our hypothesis is that in both cases these shells are constructed from a large number of identical protein molecules, of small or moderate size, packed together in a regular manner. Our hypothesis may apply, though in a slightly different form, to the ribonucleic acid component. This is discussed in more detail later.

Tobacco Mosaic Virus

This rod-shaped virus is the best studied and we shall therefore consider its structure in detail.

Tobacco mosaic virus contains 94 per cent protein and 6 per cent ribonucleic acid[7]. The characteristic particle, which is closely connected with the infectivity, has a 'molecular weight' of about 45 million, a length close to 3000 A. and a diameter of about 170 A. The early X-ray work[3] showed clearly that this particle is made up of sub-units of some sort. More recently it was realized that the basic feature of the structure is its helical nature[8]. The protein part of the virus is constructed from a large number of structurally equivalent sub-units (small globular proteins) set in helical array about the central axis. The pitch of the helix is 23 A. The number of sub-units per turn is more difficult to establish—the most probable value (Franklin, R. E., and Holmes, K. C., personal communication) gives a molecular weight for the sub-unit of about 20,000.

A very similar value is suggested by the chemical evidence. Harris and Knight[9] first examined the carboxyl end-groups of the polypeptide chains, and found that the virus particle had about 2,500 terminal groups, all threonine. This suggested that the virus contains 2,500 identical polypeptide chains, an idea which has been further strengthened by the recent work of both the Tubingen[10] and Berkeley[11] groups, who have identified the terminal three residues at the carboxyl end of this polypeptide chain.

Some additional feature is obviously needed to determine the length of the protein shell, and we would guess that in the intact virus this is controlled by the length of the ribonucleic acid core. This would explain why rods of indefinite length are produced when undenatured protein sub-units are re-aggregated in the absence of ribonucleic acid[12]. Moreover, when the re-aggregation occurs in the presence of ribonucleic acid, it is reported by Fraenkel-Conrat and Williams[13] that rods of 3000 A. in length occur very frequently.

The structure of tobacco mosaic virus, then, is based on a helix, or, in other words, it has a screw axis—in this case[8] a non-integer screw axis. This symmetry axis implies that all the protein sub-units in the body of the virus have the same environment. The same contact points between neighbouring

sub-units are used over and over again as we move along the helix. This feature is the clue to the general principle which we can apply whenever, on the molecular level, a structure of a definite size and shape has to be built up from smaller units; namely, that the packing arrangements are likely to be repeated again and again—and hence that the sub-units are likely to be related by symmetry elements.

So far we have been mainly concerned with the protein, and have neglected the ribonucleic acid component of the virus. Is that, too, made up of sub-units? The ribonucleic acid content of tobacco mosaic virus is rather low, and not more than four nucleotides can be associated with a given protein sub-unit. Now if all these groups were identical, the analytical composition of the ribonucleic acid would be based on the number 4, which it certainly is not[14]. Moreover, the ribonucleic acid is probably connected with the genetic properties of the virus, and so its fundamental unit must contain a much larger number of nucleotides.

This does not mean, however, that ribonucleic acid sub-units do not exist, since it is possible that the ribonucleic acid core contains a number of identical strands systematically interacting with the protein shell. The important consideration is that the packing arrangement should be repeated over and over again; and this can be done if the symmetry of the ribonucleic acid is the same as the symmetry of the protein and if the symmetry applies only to the sugar-phosphate backbone and not to the sequence of bases. It remains to be seen whether this type of arrangement can be established experimentally.

Spherical Plant Viruses

We have seen that the rod-shaped helical form of tobacco mosaic virus represents a natural way of constructing a large container from identical much smaller building blocks. The question we must now ask is whether the protein shell of the spherical viruses is likewise constructed by a regular aggregation of one type of small protein molecule, and, if so, how this is done. Unfortunately, there has been, to our knowledge, no systematic chemical search for the presence of sub-units in spherical viruses and so we must rely almost completely on crystallographic evidence.

It has been shown in two cases—bushy stunt virus[15] and turnip yellow mosaic virus[16]—that spherical viruses crystallize in a unit cell which has the shape of a cube; but unfortunately the X-ray photographs did not establish whether the symmetry also was cubic. This is important because, as has been pointed out by Dr. Dorothy Hodgkin[1] and Dr. Barbara Low[1], if the lattice possesses true cubic symmetry so must the virus particle, since there is only one particle in the primitive unit cell.

It has now been clearly established by Caspar (see following communication) that the unit cell of bushy stunt virus has cubic symmetry, and that, in this particular case, the virus has an even higher symmetry than the unit cell. Though this evidence applies to only one virus, we expect that further investigation will show that many small spherical viruses have cubic symmetry, for the reasons given below.

Now a virus possessing cubic symmetry must necessarily be built up by the regular aggregation of smaller asymmetrical building bricks, and this can be done only in a very limited number of ways. Since viruses are made of protein and ribonucleic acid, both of which contain asymmetric carbon atoms of one particular hand only, those symmetry elements (mirror planes and centres of symmetry) which turn a right hand into a left hand are impossible. Thus we can only have rotation axes, and for cubic symmetry this limits us to only three different combinations of symmetry elements.

Table 1. The Three Possible Cubic Point Groups for a Spherical Virus

Crystallographic description	No. and type of rotation axes present	No. of asymmetric units	Platonic solid with these symmetry elements
23	3 2-fold 4 3-fold	12	Tetrahedron
432	6 2-fold 4 3-fold 3 4-fold	24	Cube Octahedron
532	15 2-fold 10 3-fold 6 5-fold	60	Dodecahedron Icosahedron

The number of sub-units will be the same as, or a multiple of, the number of asymmetric units

Each of these three classes must contain at least four three-fold axes and three two-fold axes, arranged as for a tetrahedron. The first class contains no additional type of axis, while the second and third have four- and five-fold axes, respectively. Such an arrangement of symmetry elements is known as a 'point group', in contrast to a space group which applies to a regular arrangement extending to infinity. In Table 1 are listed the three cubic point groups possible for virus particles and also the regular polyhedra which have these symmetry elements (among others). Notice that in all these point groups the minimum number of asymmetric units must be a multiple of 12.

Three further points must be made to prevent misunderstanding. First, it is possible to arrange sub-units in other ways to produce a spherical shell, but the symmetry will not be cubic, and as they are less likely we shall not discuss them further here. Second, the asymmetric unit, upon which the symmetry elements act to build up the spherical shell, may consist of several identical sub-units joined together in some unsymmetrical fashion. This occurs quite often in protein crystals and would not be unexpected. Nor need the sub-unit be a single protein molecule in the chemist's sense of a unit joined together by chemical bonds. Several different protein molecules may aggregate to form the asymmetric unit. Third, our predictions concern the symmetry elements present in a virus particle, not its exact shape. However, this is likely to be approximately spherical, and may, under high resolution, appear polyhedral or perhaps with bumps on, like a rather symmetrical mulberry. Both these forms have been seen in electron micrographs.

It is not easy to explain in a short space why there are so few ways of building a spherical shell, but the reader can soon convince himself that it is difficult by trying to draw identical shapes which completely cover the surface of a tennis ball. It is impossible, for example, to do this entirely with hexagons, even if their shape is irregular. The point is very well stated in D'Arcy Thompson's "On Growth and Form"[17], in which we find "the broad, general principle that we cannot group as we please any number and sort of polygons into a polyhedron, but that the number and kind of facets in the latter is strictly limited to a narrow range of possibilities". The reason is essentially a topological one.

From the present X-ray evidence we are unable to distinguish the respective contributions of the protein and the ribonucleic acid, so we cannot be sure whether the cubic symmetry is perfect and applies strictly to both of them. We cannot tell whether the protein sub-units contain identical sequences of amino-acids, or whether the ribonucleic acid sub-units (if they exist) have identical sequences of nucleotides. It should not be very difficult, by end-group analysis, to decide whether the protein components are all approximately equal. By analogy with tobacco mosaic virus we would guess that this will be found to be the case. With the ribonucleic acid component, however, the problem is more difficult than it was in the case of tobacco mosaic virus, as the number of nucleotides per sub-unit is certainly much larger. (This follows from the higher percentage of ribonucleic acid[7] and the much smaller number of protein sub-units.) Only with a more detailed understanding of the ribonucleic acid core is the problem likely to be settled.

Animal and Other Viruses

For animal viruses we are handicapped because there is no X-ray evidence available so far. However, it is now becoming clear[8] that many of the smaller animal viruses, such as poliomyelitis and the various encephalitic viruses, are morphologically very similar to the spherical plant viruses. Not only are they of similar size (approximately 300 A. diameter); but it has recently been shown[10] that poliomyelitis virus also contains ribonucleic acid and can form crystals which appear as regular as those produced by the plant viruses. We thus think it very probable that cubic symmetry also extends to these animal viruses, and that the soluble antigens[10] (of about 120 A. diameter) frequently observed in infected cells are related to the sub-units normally used in the assembly of the final infective virus.

We also see no reason why our hypothesis should not be valid for viruses containing deoxyribonucleic acid rather than ribonucleic acid. Although the structure of bacteriophages is usually more complex than the smaller viruses discussed here, the fact that their heads appear polyhedral suggests that ideas of this general type may apply to them, too. On the other hand, it is less likely that they will be relevant to the structure of the larger viruses like vaccinia.

Conclusion

We can now describe our hypothesis in a more general manner. We assume that the basic structural requirement for a small virus is the provision of a shell of protein to protect its highly specific packet of ribonucleic acid. This shell is necessarily rather large, and the virus, when in the cell, finds it easier to control the production of a large number of identical small protein molecules rather than that of one or two very large molecules to act as its shell. These small protein molecules then aggregate around the ribonucleic acid in a regular manner, which they can only do in a limited number of ways if they are to use the same packing arrangement repeatedly. Hence small viruses are either rods or spheres. The number of sub-units in a rod-shaped virus is probably unrestricted, but for a spherical virus the number is likely to be a multiple of 12. Every small virus will contain symmetry elements and in favourable cases these can be discovered experimentally

We believe that this hypothesis is likely to apply (in this form or a simple variant of it) to all small viruses which have a fixed size and shape.

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Structure of Bushy Stunt Virus

Crystals of bushy stunt virus yield detailed X-ray diffraction patterns indicating a high degree of regularity in the virus structure. Bernal, Fankuchen and Riley[1] found that the unit cell is body-centred cubic with one virus particle per primitive lattice point. Previous X-ray photographs[1,2] did not show whether the symmetry as well as the shape of the lattice is cubic. This is of considerable interest, since cubic symmetry for the lattice would imply that the individual virus particles possess cubic symmetry[3]. This is discussed in the preceding article (by Crick, F. H. C., and Watson, J. D.).

Precession photographs have been obtained from single crystals of bushy stunt virus which were grown by Messrs. F. C. Bawden and N. W. Pirie and kindly supplied by Dr. C. H. Carlisle. Two of these photographs, showing the basal reciprocal lattice planes normal to the edge and body diagonal of the cubic unit cell, are illustrated in Figs. 1 and 2. These show two- and three-fold symmetry respectively about the cube edge and cube diagonal, and establish the space group as $I\,23$ ($a = 386$ A.).

Early in this study, photographs were obtained from a disordered crystal which did not give lattice

reflexions but in which the relative orientation of the virus particles appears to have been maintained. In one particular orientation this crystal gave a pattern of diffuse reflexions lying in several rings, each of which contained ten symmetrically arranged spots. This suggests that the virus particle has five-fold as well as two- and three-fold symmetry.

If the virus has the point-group 532, rather than merely 23, it will have additional symmetry axes. There will be one set each of two-fold, three-fold and five-fold axes lying in non-crystallographic directions, as well as the set of two-fold and the set of three-fold axes belonging to the space group. The directions of members of each of these five sets are shown in Figs. 1 and 2, except for the three-fold axes of the space group which can be seen in another photograph not reproduced here.

The intensity distribution which such symmetry is likely to produce on an X-ray photograph is best considered by reference to the Fourier transform of an individual virus particle. It can be shown that this transform is likely to exhibit spikes of high intensity extending from the origin along the direction of the symmetry axes. The X-ray pictures actually confirm the existence of such spikes along the postulated axes. The only difficulty in the identification arises from the fact that the symmetry of the crystal lattice (23) is lower than that of the individual virus particles (532). This means that directions in the transform which are related by the symmetry of the virus particle have to be sampled on reciprocal lattice points which have no symmetry relation, and the arrangement of which tends to obscure or confuse the underlying symmetry of the transform. However, allowing for this sampling difficulty, it is found that the radial variation of intensity near one type of diad of the point groups 532 is very similar to that near the other type; this is exemplified especially by regions of zero intensity occurring at the same distance from the origin along both types of dyads. A similar correspondence is also found for the two types of triads. Moreover, the intensity variations along the dyads and triads are different.

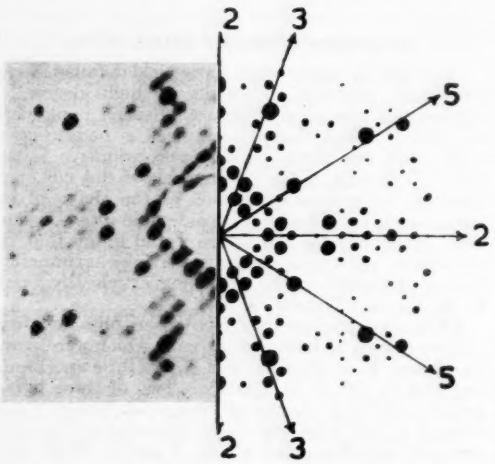

Fig. 1. Precession photograph of basal reciprocal lattice plane normal to the cube edge of bushy stunt virus crystal (left). Weighted reciprocal lattice net showing the orientation of the two- three- and five-fold axes of the point group 532 which lie in this plane (right). The two-fold axes in this plane lie along the [100] directions of the lattice

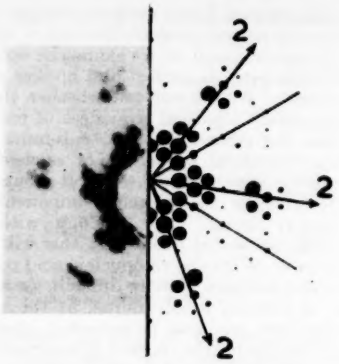

Fig. 2. Basal reciprocal lattice plane normal to cube diagonal showing the orientation of the two-fold axes of the point group 532 which lie in this plane. The unlabelled lines lie along the [110] directions of the lattice

All the evidence indicates that the virus has the point-group symmetry 532, which implies that it is built up of sixty structurally identical asymmetric units. The molecular weight of bushy stunt virus is about 9 million[4], of which about 17 per cent is ribonucleic acid[5]; therefore, the molecular weight of the protein part of the asymmetric unit is about 125,000. The point group symmetry does not preclude the possibility of each crystallographic unit being subdivided further into a number of chemically identical protein molecules. Thus 125,000 is a maximum value for the size of the protein sub-unit.

Chemical evidence, in fact, does suggest that the protein sub-unit may perhaps be smaller than this. There have been no end-group analyses reported for bushy stunt virus, but its amino-acid analysis obtained by de Fremery and Knight[5] can be used to calculate the minimum size of the sub-unit. Tryptophan, cysteine, methionine and histidine are present in very small amounts and approximately in the molar ratio 1 : 2 : 2 : 3. Assuming that all the protein molecules in the virus are identical (which may not be true) these analyses give a minimum molecular weight of 25,000–28,000, suggesting perhaps three hundred protein sub-units.

Thus the X-ray evidence shows that bushy stunt virus possesses sub-units. The number of sub-units is certainly a multiple of twelve and very probably a multiple of sixty. The chemical data suggest that the actual number may be as high as three hundred.

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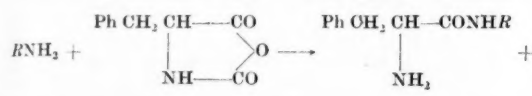
LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

The 'Chain Effect': a Possible Analogue of Enzyme Action

We wish to report a novel type of reaction in which the polymerization of DL-phenylalanine N-carbonic anhydride is initiated by polysarcosine (as dimethylamide). This reaction, which has brought to light some features that are potentially of general importance in reactions involving polymers, shows marked analogies with processes in which enzymes function as catalysts.

The normal propagation reaction in the polymerization of DL-phenylalanine N-carbonic anhydride initiated by primary or secondary bases is:



(1)

and when carried out in nitrobenzene solution at 15°, it has[1] a bimolecular rate constant of 0·6 mole^{-1} l. min.$^{-1}$. However, if polysarcosine with a degree of polymerization (n) of about 20 is used as initiator, the ensuing reaction may be several hundred times as fast as would be expected on the basis of this rate constant. The initial rate of reaction, measured for a given polysarcosine concentration, is a function of n as shown in Fig. 1. The rate of the normal propagation reaction obtained with non-polymeric initiation for the same concentrations of anhydride and base is only 3×10^{-4} mole l.$^{-1}$ min.$^{-1}$ and is indistinguishable from zero in the graph. It is evident that the polysarcosine chain is capable of exercising a remarkable catalysis upon the reaction, and we designate this the 'chain effect'.

When low concentrations of polysarcosine are employed, the rate of reaction, initially high, may fall to the value corresponding to the normal propagation reaction after a comparatively small degree of conversion, and unchanged anhydride remains in solution. Titration of the reaction mixture shows that the base groups are still free at this stage, no acid formation being detectable in the system. It seemed likely that the reaction product—poly-DL-phenylalanine—was an inhibitor, and this has been confirmed by experiments in which this polymer was added initially. Under these conditions no rapid reaction was observed.

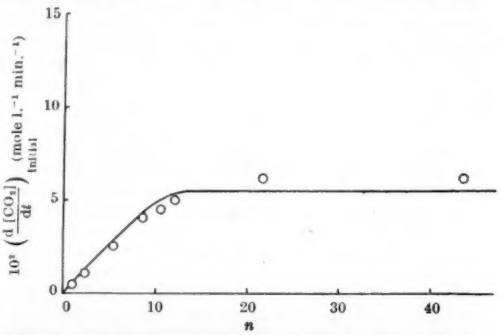


Fig. 1. Dependence of initial rate on length of polysarcosine chain. Reaction in nitrobenzene at 15° C. $[M]_0 = 0{\cdot}1$ mole l.$^{-1}$, concentration of polysarcosine dimethylamide = $0{\cdot}54 \times 10^{-2}$ mole l.$^{-1}$. ○, Experimental points; full curve calculated on the basis of equations 2(*a*), (*b*)

In order to observe the chain effect in the system described, it is necessary for the polysarcosine chain to carry a terminal base group. If this is acetylated, no reaction occurs. Addition of a primary or secondary base (for example, piperidine) to the solution containing anhydride and acetylated polymer leads to a reaction which has only about a tenth of the rate of that due to the chain effect, indicating that the base is much more effective when attached to the polysarcosine chain.

We believe that the chain effect arises as a result of attachment of the anhydride molecules to the polysarcosine chain, probably by hydrogen bonding between the >NH groups of the former and the >CO groups of the polymer. Polysarcosine would be expected to be particularly effective in this respect, since it contains no >NH groups, and is therefore unable to form inter-peptide hydrogen bonds. On the other hand, poly-DL-phenylalanine, which contains >NH groups, does not give rise to the chain effect. As a result of the 'adsorption' of the anhydride by the polysarcosine, the concentration of anhydride in the proximity of the base is greatly increased, and since the polysarcosine chain is fairly flexible, the collision frequency between the base and the anhydride is much higher than that calculated on the basis of the overall concentrations of the reactants. Calculations of the order of magnitude suggest that this mechanism is sufficient to account for the high rate observed, even if it is assumed that the reactivity of the anhydride is not increased by adsorption. The chemical changes occurring are probably essentially similar to those in (1), and the final product is a block copolymer of sarcosine and poly-DL-phenylalanine. The process described would not operate when unattached base and acetylated polysarcosine are used, but hydrogen bonding between base and polymer may be sufficient to give a small degree of attachment.

The inhibition of the reaction by poly-DL-phenylalanine is readily understandable on this mechanism, since this polymer would form interchain hydrogen bonds with the polysarcosine, leading to aggregates of chains in which the accessibility of the adsorbed anhydride to the base is low, for steric reasons. Further, it would be expected that the nature of the solvent would be an important factor. This is so in practice; the chain effect in NN-dimethylformamide solution is only small. This liquid is capable of hydrogen bonding to the anhydride and the polymer, and this will reduce the adsorption of the anhydride by the polymer. N-substituted carbonic anhydrides should not show the chain effect unless the substituent carries a strong hydrogen-bonding group.

The observed dependence of the initial rates of reaction upon the experimental variables (n, anhydride concentration $[M]$ and sarcosine residue concentration $[S]$) is accounted for by the following simple kinetic scheme:

$$\begin{aligned} S + M &\rightleftharpoons E \qquad (a) \\ E &\rightarrow \text{products} \qquad (b) \end{aligned} \qquad (2)$$

where E represents an adsorbed DL-phenylalanine N-carbonic anhydride molecule. The equilibrium in

2(*a*) is supposed to be maintained throughout the reaction; the rate-determining step 2(*b*) requires the intervention of the base group at the end of the chain upon which *E* is situated, but this does not, of course, appear in the kinetic equations. The products in 2(*b*) are carbon dioxide and a phenylalanine residue which becomes joined to the terminal base group. The kinetic behaviour is quite different from that observed with the normal propagation reaction.

The process giving rise to the chain effect may therefore be visualized as the growth of one polymer on the surface of another in solution. It has analogies with heterogeneous reactions at interfaces. Of greater interest is the possible analogy with enzymic reactions. The dependence of the rate of the polymerization reaction upon the experimental variables, which is usually of the form shown in Fig. 1, resembles that found with enzymic reactions, and indeed the scheme (2) is similar to the simple Michaelis–Menten mechanism. The importance of the resemblances between the two types of system should become clearer with further work with other polymers and reactants.

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Carbohydrases in Blow-fly Larvæ

Hobson[1] showed that glycerol and/or dried preparations of the gut and salivary glands of *Lucilia sericata* Meig. showed strong proteinase activity but very little carbohydrase activity, only starch being hydrolysed, whereas maltose, sucrose and lactose were not hydrolysed at all. Since that report, these results have been quoted[2] to support the plausible example of adaptation, wherein larval and adult blow-flies are assumed to possess digestive ability corresponding to their diet. Thus larvæ feeding on a protein-rich diet are adequately provided for because the gut shows strong proteolytic activity and the lack of carbohydrases is of no consequence. The reverse picture is presented in adult blow-flies which feed principally on carbohydrates; very active carbohydrases are present but only relatively weak proteinases.

However, Evans[3] has recently established that gut tissues from the larvæ of *Calliphora erythrocephala* Meig. are able to hydrolyse a wide range of carbohydrates, there being little difference in this respect between larvæ and adults. Using the same techniques, it has now been demonstrated that *Lucilia sericata* larvæ are also capable of hydrolysing a wide range of carbohydrates. The salivary glands or gut tissues were incubated on a welled microscope slide in buffered substrate (*p*H 6·8) which had previously been saturated with toluene. Hydrolysis of non-reducing substrates was readily detected by placing the slides on a hot plate after the addition of Benedict's sugar reagent and noting the appearance of red cuprous oxide. Any change in sugar content of reaction mixtures with reducing substrates was determined by paper chromatographic analyses of samples of the reaction mixture before and after incubation. In all experiments suitable controls using denatured tissues were always employed.

The following substrates were hydrolysed by salivary gland and mid-gut tissue from *Lucilia* larvæ: maltose, sucrose, trehalose, α-methyl galactoside, raffinose, melezitose, starch; whereas the following were not hydrolysed: α-methyl glucoside, lactose, melibiose, cellobiose, cellulose.

These results, which are similar to those obtained for *Calliphora*, are of interest in relation to the problems of carbohydrase specificity. Fraenkel[4] explained the ability of adult *Calliphora* to digest a range of carbohydrates by assuming the bond-specificity concept of Weidenhagen[5]. So far as the disaccharides and trisaccharides were concerned, only enzymes capable of splitting α-glucoside and α-galactoside linkages were required to be present. However, the carbohydrase activity of larval blow-fly tissues cannot be accounted for so easily because: (1) α-methyl glucoside is not hydrolysed, unlike all the other sugars containing an α-glucoside bond, namely, maltose, sucrose, trehalose and melezitose; (2) α-methyl galactoside is hydrolysed, but melibiose, another α-galactoside, is not. It is clear that the properties of larval blow-fly carbohydrases do not completely exemplify Weidenhagen's hypothesis of bond specificity, the over-generalized nature of which has been criticized more recently[6]. Much more information about the properties of animal carbohydrases is necessary to give a satisfactory explanation of the ability to digest certain carbohydrates and not others in terms of bond specificity or otherwise.

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Comparative Anticœstrogenic Potencies of Progesterone and 17α-Hydroxyprogesterone

Progesterone is known to be not only a progestational compound but also to exert various anticœstrogenic actions: it prevents œstrogen-induced abdominal fibroids, œstrogen-induced growth of the myometrium, and œstrogen-induced excessive luteinization[1]. The anticœstrogenic potency of progesterone is diminished by oxidation at C_{21}, C_{11} and C_{17} [2,3]. The validity of this rule has been demonstrated by comparing progesterone with C_{11}-derivatives such as 11β-hydroxyprogesterone and 11-keto-progesterone, and with a C_{21}-derivative such as deoxycorticosterone. As to oxidation at C_{17}, comparison was made between deoxycorticosterone and Reichstein's compound *S* or 17α-OH-11-deoxycorticosterone[3]. Thus the conclusion as to loss of anticœstrogenic potencies due to oxidation at C_{17} in the α-position has been so far an indirect one; a comparison of progesterone with 17α-hydroxyprogesterone was still lacking. Results with the latter are given in the present communication.

Table 1. TWENTY-TWO CASTRATED FEMALE GUINEA PIGS RECEIVING ŒSTRADIOL AND 17α-HYDROXYPROGESTERONE OVER A PERIOD OF THREE MONTHS

No. of animals	Œstradiol per day (μgm.)	17α-hydroxy-progesterone per day (μgm.)	Fibrous tumoral effect (ref. 2)	Coeff. Q_{2-3} (ref. 2)	Uterine weight (gm.)	No. of pellets and concentration of 17α-hydroxyprogesterone
6	51	9 (8–10)	5·9 ± 1·1 (2–9·5)	1·5	4·4 (2·3–6·5)	½ ; 40%
10	43	16 (13–19)	8·5 ± 0·4 (7–11)	2·9	5·7 (2·7–11·8)	½–1 ; 40%
6	44	136 (123–145)	7·5 ± 1·5 (2·5–12)	2·2	6·8 (5·2–13·0)	1 ; 100%

Pellets of 17α-hydroxyprogesterone were implanted beneath the skin of castrated guinea pigs; pellets of œstradiol also were implanted. Absorption was of 2·1 μgm. per sq.mm. of 17α-hydroxyprogesterone, against 3·3 μgm. of progesterone. Results for twenty-two animals receiving œstradiol and 17α-hydroxyprogesterone are given in Table 1; comparison between fifty-two animals receiving œstradiol and progesterone[4] is made in Fig. 1.

As seen from the table, neither œstrogen-induced abdominal fibroids nor uterine growth was prevented with as much as 136 μgm. of 17α-hydroxyprogesterone a day. On the other hand, as seen in Fig. 1, the fibrous tumoral reaction with 15 μgm. of progesterone per day was only 1·5 against 7·5 with amounts of 17α-hydroxyprogesterone eight or nine times greater than that. The coefficient Q_{2-3}, which refers to incidence of larger tumours only, was no less than 2 with 16 μgm. and even with as much as 136 μgm. of 17α-hydroxyprogesterone (Table 1); on the other hand, Q_{2-3} was zero with 15 μgm. of progesterone[4]. In Fig. 2 the maximal œstrogen-induced fibrous reaction in the presence of 13–24 μgm. of progesterone per day is compared with the non-maximal reaction in the presence of 123–145 μgm. of 17α-hydroxyprogesterone per day.

Uterine weight was 2·8 gm. and 5·7 gm. with 15 μgm. of progesterone and 17α-hydroxyprogesterone respectively (Fig. 1).

It is also of interest to compare results obtained with 17α-hydroxyprogesterone with those obtained with C_{11} and C_{21} derivatives of progesterone: as to antifibromatogenic and antihysterotrophic potencies, it is inferior to 11β-hydroxyprogesterone, to 11-keto-progesterone and to deoxycorticosterone[2].

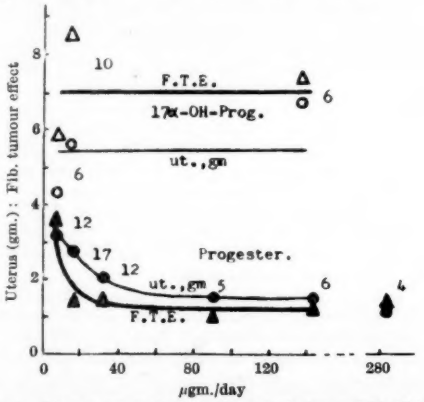

Fig. 1. Fibrous tumoral effect (△) and uterine weight (○) of twenty-two castrated females receiving œstradiol and 17α-hydroxyprogesterone, compared with 52 castrated female guinea pigs receiving œstradiol and progesterone (▲ and ●). Figures indicate number of animals in the group. (Variations of fibrous reaction and uterine weight with 17α-hydroxyprogesterone are considerable; see also Table 1. But these differences between the 17α-hydroxyprogesterone groups are not significant and thus of no interest. The average in animals receiving only œstradiol may vary, according to the groups, between 4 and 7 or more)

Thus, there is full evidence that with oxidation at C_{17} the antiœstrogenic potencies of progesterone are diminished and in a manner seemingly more pronounced than with oxidations at C_{11} or C_{21}.

Comparative results as to antiœstrogenic potencies of progesterone and the oxy-derivatives mentioned are of considerable interest because the latter occur also in the body of mammals[5]. But results with 17α-hydroxyprogesterone deserve special attention in view also of recent findings with its caproate ester: whereas the free compound administered to women by intramuscular injection is without progestational action, the caproate ester is progestational[6]—apparently 're-acquired' through esterification. We have not yet examined whether antiœstrogenic potencies are also re-acquired by the caproate ester of 17α-hydroxyprogesterone.

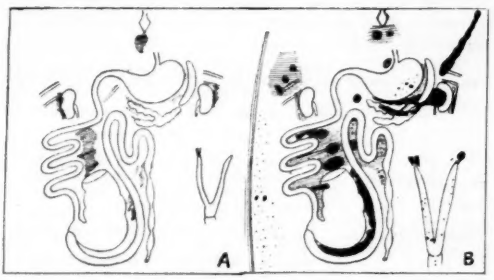

Fig. 2. Fibrous tumoral effect. Solid black surface, massive fibrous tumours; shaded areas, fibrous strands. (*A*) Maximal fibrous reaction in a group of seventeen animals receiving during three months œstradiol and 13–24 μgm. of progesterone per day. Fibrous tumoral effect, 1·5. (*B*) Non-maximal fibrous reaction in a group of six animals receiving œstradiol and 123–136 μgm. of 17α-hydroxyprogesterone per day. Fibrous tumoral effect, 10

Thanks are due to Prof. Carl Djerassi, of Wayne University, for the sample of 17α-hydroxyprogesterone, and to Syntex, S.A., Mexico, for a generous supply of œstradiol.

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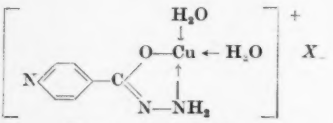
Mode of Action of *Isonicotinic Hydrazide*

In our earlier report we directed attention to the importance of chelation as an essential step in the anti-tuberculous activity of *iso*nicotinic hydrazide (isoniazid)[1]. It was impossible to decide whether the chelating action with a metal or metals took place before (in the medium) or after adsorption on the bacterial cell.

Since then we have had the opportunity of examining the activity *in vitro* and *in vivo* of the relatively insoluble cupric complex of isoniazid:



X_- = a univalent anion

The results now reported (see Table 1) indicate that this complex is highly active. Thus, it might now be postulated that isoniazid is probably inactive in the absence of a chelating metal, and that its anti-tuberculous activity is, in fact, due to its metal complex, in this instance the cupric derivative. These findings are strongly reminiscent of those obtained in earlier studies of the mode of action of 8-hydroxyquinoline (oxine)[2].

Table 1. Activity of *iso*Nicotinic Hydrazide and its Cupric Chelate Complex

Compound	Anti-tuberculous activity		
	In vitro (ref. 5) Tuberculostatic end-point. Medium: synthetic serum-synthetic		*In vivo* (ref. 3) Healing ulcer response
*Iso*nicotinic hydrazide (isoniazid)	2,048,000 (0·07 μgm./ml.)	2,048,000 (0·07 μgm./ml.)	20 mgm./kgm. weekly I.M. *HR* 100 in 28 days.
Cupric complex of isoniazid	4,096,000 (0·08 μgm./ml.)	512,000 (0·6 μgm./ml.)	20 mgm./kgm. weekly I.M. *HR* 99 in 28 days.

It will be noted that the activity *in vivo*, examined by the healing-ulcer technique previously reported[3], is extremely high, two injections effecting 85 per cent cure (*HR* value 85) in three weeks and 99 per cent cure in 28 days after three injections.

This copper derivative appears to be as active as isoniazid, verazide[4] or any drug we have tested so far. However, it exhibits a profound local and general toxicity in mice and guinea pigs. During treatment of guinea pigs by intramuscular injection, a severe gangrenous necrosis and ulceration developed at the site of injection, and in mice the acute toxicity (*LD*50) was as low as 36 mgm./kgm. body-weight compared with 200 mgm./kgm. for isoniazid itself.

The interest in these findings centres on the demonstration that the copper-isoniazid chelate complex is active *in vitro* and *in vivo* under conditions in which it is unlikely to break down to isoniazid. This observation, taken in conjunction with our earlier findings[1], has led us to conclude that the anti-tuberculous activity of isoniazid is expressed after it has formed a chelate metal complex in the medium or the animal body in which it is acting. The identity of the complexing metal *in vitro* or *in vivo* is still unknown, and the activity of other metal complexes is being investigated.

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Reduction to Normal Levels of the High Erythrocyte Sedimentation-Rates in Apparently Healthy South African Bantu Men

In the tropics and semitropics, unusually high values for erythrocyte sedimentation-rates are common among apparently healthy individuals. Thus, among seventy-five medically fit young Indian medical students, the mean rate (Wintrobe's method)[1] was 11·2 ± 9·4, range 0·5–30 mm.; high values are assumed to be pathological, although the cause was unknown[2].

Neither malnutrition nor under-nutrition (unless very severe) is believed directly to influence erythrocyte sedimentation-rate[3]. Nevertheless, we find that although very high rates are common among different regional groups of apparently healthy Bantu mine-workers, the mean high values become reduced to within normal limits after subjects, without any medical treatment, have consumed for four–fifteen months the excellent diet provided in the mine compounds.

The Bantu mine-workers were eighteen to forty years old, in good physical condition, not anæmic, and free from radiological tuberculosis. No significant enlargement of liver, spleen or lymph nodes was apparent. Subjects were variously parasitized, particularly the tropical group. The Kolmer–Wassermann test for syphilis was positive in 4 per cent of cases. The majority showed liver dysfunction as revealed by the common biochemical tests on serum.

Workers came from areas where the diet is usually adequate in calories and gross protein, but is low in animal protein, fat and certain mineral salts and vitamins. The mine compound diet, which may be eaten to satiety, is nutritionally adequate.

The erythrocyte sedimentation-rate was determined on oxalated blood using Wintrobe's method[1], two technicians working in parallel, and determinations being completed within 3 hr.

In Table 1, only in the mixed group do data refer to the same individuals examined at the beginning and end of periods of service.

Our results revealed an equal degree of abnormality of erythrocyte sedimentation-rate among recruits with and without previous periods of service in the mines: this finding suggests that the normal values found on leaving the mines rise again on returning for some months to conditions of tribal life.

The dramatic and unexpected changes in erythrocyte sedimentation-rate found in these outwardly healthy subjects are not due to any medical treat-

Table 1. Sedimentation-Rates in Bantu Mine-workers at the Beginning and End of Periods of Service

Subjects	Mean erythrocyte sedimentation-rate, standard deviations, ranges, and (in brackets) number of subjects	
	Values at beginning of service	Values after 4–15 months period
Eastern Transvaal and Moçambique (Shangaans)	11·5 ± 11 (75) 1–35	3·5 ± 2·5 (25) 0·5–10
Transkei (Pondos and Xosas)	12 ± 9 (47) 2–38	3·0 ± 2·5 (31) 0·5–11
Nyasaland, Angola, Northern Rhodesia (Tropical group)	29 ± 10 (75) 1–49	3·5 ± 4·0 (30) 1–11
Mixed group	16 ± 11 (15) 1–43	3·0 ± 2·5 (15) 1–9

ment, and we are driven to ascribe the changes directly, or indirectly, to the consumption of an excellent diet for several months. The precise explanation and significance of our observations remain to be established; nevertheless, it is suggested that in future studies on the nutritional status of non-white populations, determinations of erythrocyte sedimentation-rate may contribute valuable information.

We are grateful to Dr. R. C. Pearson and the late Dr. R. M. Yeo, of the Witwatersrand Native Labour Association Hospital, who facilitated the collection of blood from some of the groups of Bantu mine-workers, and to Miss G. McNab, of this Institute, for carrying out the Kolmer–Wassermann tests. This communication is published with the permission of the South African Council for Scientific and Industrial Research.

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Effect of a Coliform Organism (*Escherichia*) on the Second Ecdysis of Nematode Larvæ parasitic in the Horse

It was recently shown that third-stage infective larvæ of the family Strongylidae commonly parasitic in the horse would readily shed their protective sheaths in equine duodenal contents[1]. Similar results have also been obtained by Sommerville[2] using ovine material.

The effect of artificial duodenal contents prepared according to the formula given by Silverman[3] has recently been observed using infective equine nematode larvæ. Results using the fresh solution proved disappointing. In three separate experiments the average percentage ecdysis only reached 13·6 after five hours.

It was noted that artificial duodenal contents, kept in a laboratory where horses' fæces are regularly examined and where no special precautions were taken to preclude entry of bacteria, developed after five days an offensive odour reminiscent of equine duodenal contents. Larvæ of the same age as those used above were therefore placed in the contaminated solution and the degree of ecdysis observed. This reached 80 per cent after three hours and increased to 89 per cent after five hours. It seemed, therefore, that the contamination of the artificial duodenal contents had enhanced its power to induce ecdysis.

A coliform organism was afterwards isolated from the contaminated solution, and it was therefore thought that it might be profitable to assess the effect of bacteria of this type on the rate of ecdysis.

Accordingly, artificial duodenal contents were freshly prepared. The solution was passed through a Seitz filter, after which it was divided into two equal portions, one of which was inoculated with a known coliform organism (*Escherichia*) of equine origin. This was incubated at 37° C. overnight. Larvæ of the same age were placed in both solutions and the rates of ecdysis compared. Fig. 1 illustrates the results obtained. There can be no doubt that the presence of the coliform organism has accelerated the rate of ecdysis. At present, four coliform organisms

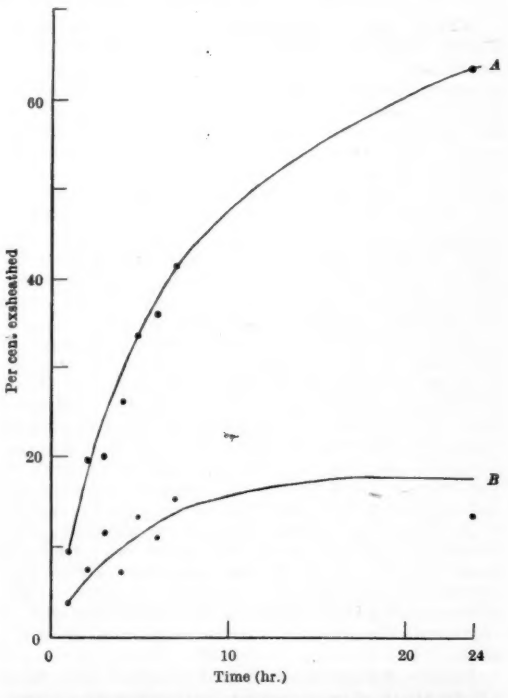

Fig. 1. The percentage of larvæ undergoing ecdysis plotted against the time in hours. Curve *A* shows the results in Seitz-filtered artificial duodenal contents plus coliform organisms (*Escherichia*). Curve *B* shows the results in Seitz-filtered artificial duodenal contents alone

(*Escherichia*) of different equine origin have been used and all have accelerated the rate of ecdysis.

Experiments have also been conducted using Seitz-filtered natural equine duodenal contents. Larvæ placed in this have never undergone great degrees of ecdysis, 9 per cent after twenty-four hours being the greatest yet recorded. In unfiltered duodenal contents, ecdysis regularly reaches 90–100 per cent before this time.

In all these experiments, mixed larvæ of the family Strongylidae were used. These were obtained from charcoal cultures of equine fæces, and it is likely that small amounts of bacteria were present on them, despite the fact that they were washed in sterile distilled water before use.

It is concluded that the presence of coliform organisms is necessary for the normal occurrence of the second ecdysis of nematode larvæ of the family Strongylidae commonly parasitizing the horse.

I wish to thank L. W. Mahaffey for advice on coliforms and supplies of pure cultures.

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Adrenergic Sweating in Cattle

Cattle skin is abundantly supplied with sweat glands[1], and these glands have been suggested to be functional[2,3]; but very little is known about the secretory control. Muto[4] recorded that adrenaline produces marked sweating in horses and sheep but has no effect on the calf. Ferguson and Dowling[3], on the other hand, observed the formation of sweat droplets in the calf in response to intradermal injections of adrenaline. Precise information, however, on whether the control of sweat glands of cattle is adrenergic and/or cholinergic is still lacking. We have therefore extended our experimental work on the cutaneous evaporation in cattle, in order to test the response of sweat glands to some of the drugs affecting the sympathetic nervous system.

An American Brahman calf, between the ages of three and seven months, was exposed at intervals to an air temperature of 108° F. dry-bulb and 80° F. wet-bulb. Cutaneous evaporation was measured from the shoulder area using a semicircular capsule made of 'Perspex', with an area of 19·6 sq. cm. Hot-room air was circulated through this capsule at the rate of 2·5 lit./min. At frequent intervals, the hot air was passed, after it had circulated over the skin under the capsule, through an absorber (concentrated sulphuric acid), and at the same time the same quantity of air at the same rate of flow was passed through another identical absorber. The difference of gain in weight between the two absorbers represents the amount of water evaporated from the skin.

Results presented in Fig. 1 indicate that N-(2-chloroethyl) dibenzylamine hydrochloride (dibenamine) given intravenously at the rate of 7 mgm./kgm. body-weight gradually reduced sweating. Sweating was completely blocked three hours after the injection. During the course of adrenergic blockade, intradermal injections of adrenaline and noradrenaline (0·2 mgm.) given near the site of the capsule failed to stimulate sweating. On the following day, the blockade of adrenaline action gradually diminished until the sweating-rate returned to its initial level; at this stage, injection of adrenaline increased the sweating whereas noradrenaline remained ineffective. The action of dibenamine on cattle sweat glands is therefore similar to that on human sweat glands[5].

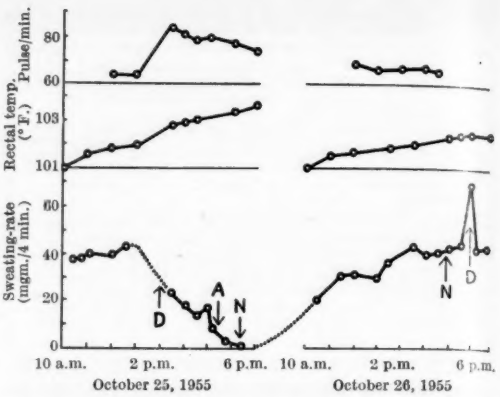

Fig. 1. Effect of dibenamine, adrenaline and noradrenaline on sweating-rate, rectal temperature and pulse-rate of a calf. Dotted lines indicate unmeasured intervals. Dibenamine (*D*), adrenaline (*A*) and noradrenaline (*N*) administered at points marked by arrows. Room temperature 108° F. dry bulb and 80° F. wet bulb

The inhibition of sweating induced by dibenamine was accompanied by increase in rectal temperature and pulse-rate with a room temperature of 108° F. As the sweating gradually increased on the following day, the pulse-rate and the rectal temperature were found to be below the levels recorded during administration of dibenamine. Intramuscular injections of dibenamine caused inhibition of sweating; but local subcutaneous administration of 2 mgm. of 2-benzyl 2-imidazoline (priscol), another adrenergic blocking agent, did not reduce sweating. A higher dosage of priscol (10 mgm.), on the other hand, caused profuse sweating similar to that in man[6].

There was no response of sweat glands to subcutaneous injections of atropine (60 mgm.) and acetylcholine (0·2 mgm.), but the injections of adrenaline given at the shoulder region increased the sweating-rate on the average from 32·1 to 45·5 mgm./cm.²/hr. Cattle sweat glands appear, therefore, to be adrenergic, in this way differing from those of man, which are both adrenergic and cholinergic.

Thanks are due to Prof. W. V. Macfarlane for his assistance, advice and encouragement.

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Transfer of Hydrogen from Alcohols to Quinones

WHEREAS an extensive study of hydrogen abstraction by methyl radicals in the gas phase has been reviewed[1], hydrogen transfer in solution has only recently been discussed and the various types classified[2] as an introduction to a general study of this phenomenon: in particular, some hydrogen transfers to quinones in solution have been studied[3]. It is therefore pertinent to indicate briefly the conclusions drawn from the determination of the reactivity of some simple alcohols to photo-oxidation sensitized by quinones.

Bolland and Cooper[4] have concluded from a variation of the quantum yields of reaction products with experimental conditions that alcohols are attacked by photo-excited anthraquinones A^* with the production of semiquinones $\cdot AH$ as follows:

$$A^* + RCH_2OH \rightarrow \cdot AH + \dot{R}CHOH \qquad (a)$$

$$\dot{R}CHOH + O_2 \rightarrow R\dot{C}H(OH)(O_2\cdot) \qquad (b)$$

the subsequent reactions of the hydroxyperoxy radicals leading to the formation of stable products.

It has been found from a kinetic study of the reaction using sodium anthraquinone-2-sulphonate in aqueous solutions that the reactivity of the alcohols to hydrogen transfer can be determined from measurements of the rate of oxygen uptake of the system under varying conditions. The following are reactivities determined for some simple alcohols:

Substrate	Reactivity per >COH group relative to ethanol
Methanol	≃ 0·12
Ethanol	1·00
n-Propanol	1·53
n-Butanol	2·07
*Iso*propanol	2·14
tert. Butanol	~ 0·01
Ethylene glycol	0·289
1,2-Propylene glycol	0·625
2,3-Butylene glycol	1·49
Glycerol	0·280

Thus: (i) in the primary alcohols reactivity increases with increasing chain-length; (ii) in the glycols, reactivity increases with increasing methylation of the carbon atoms in the α-position to the hydroxyl groups; (iii) reactivity increases in the monohydric alcohols with increasing alkylation on the α-carbon atom until all hydrogen atoms are replaced, when a great reduction in reactivity results, that is, reactivity increases along the series *t*-BuOH ≪ MeOH < EtOH < *iso*PrOH; (iv) increasing hydroxylation of propanol produces a decreasing reactivity, that is, reactivity decreases along the series *n*-PrOH > propylene glycol > glycerol.

The increase in reactivity with increase in alkylation is in accord with trends of reactivity observed in cases of hydrogen transfer from the α-carbon atom of primary and secondary alcohols to other acceptors both in the vapour and liquid phases[1,5]. Observation (iv) would suggest that hydration has a hindering effect on the hydrogen transfer process. The above results were determined in neutral solution. However, using *iso*propanol, the reactivity to photo-excited sensitizer has been found to decrease with increasing acidity; this has been adequately interpreted in terms of formation of an oxonium ion $R_2CH\dot{O}H_2$, which is unreactive compared with the alcohol itself. On this assumption a detailed analysis of the kinetics gives the value of

$$K_b = \frac{[(CH_3)_2CH\dot{O}H_2]}{[(CH_3)_2CHOH][H^+]}$$

for

$$(CH_3)_2CHOH + H^+ \overset{K_b}{\rightleftharpoons} (CH_3)_2CH\dot{O}H_2$$

as 2·5 litres mole^{-1} at 0° C.

For the thermal hydrogen transfers between hydroaromatic compounds and quinones, which are accelerated by acid conditions, Braude *et al.*[3] have suggested a slow transfer of a hydrogen anion to the quinone followed by a rapid transfer of a proton. The heterolytic fission of the α C—H bond in the alcohols is unlikely to occur in these photochemical transfers as it would produce the ion $R_2\dot{C}OH$, which could not yield by interaction with oxygen the $RO_2\cdot$ radical, a necessary intermediate in the formation of the stable products. Straightforward hydrogen atom transfer[6], and electron transfer[7] (in this case from the oxygen of the alcohol; Kenner, private communication) followed by proton expulsion, have been proposed as mechanisms for photo-oxidations sensitized by dyestuffs. For the alcohols:

hydrogen atom transfer:

$$A^* + RCH_2OH \longrightarrow \cdot AH + \dot{R}CHOH \qquad (a)$$

electron transfer:

$$A^* + RCH_2OH \xrightarrow{\text{slow}} \cdot A^- + R\dot{C}H_2OH \qquad (c)$$

$$R\dot{C}H_2OH \xrightarrow{\text{fast}} \dot{R}CHOH + H^+ \qquad (d)$$

The increase in reactivity with increase in alkylation on the α-carbon atom of the alcohols discussed above could be consistent with either hydrogen atom transfer or electron transfer, with the increasing inductive effect assisting the removal of the hydrogen atom or the electron. However, on the electron-transfer mechanism the rate-determining process (*c*) would be expected to be more facile with *tert.* butanol than with *iso*propanol. A detailed consideration of the mechanism shows that any difference in the subsequent behaviour of the radical of *tert.* butanol from those of the primary and secondary alcohols would change the rate of oxygen uptake, and hence the reactivity, by a factor of only two or three, since the rapid reversion of semi-quinone to quinone:

$$\cdot AH(\cdot A^-) + O_2 \rightarrow A + HO_2\cdot (\cdot O^-_2)$$

must still operate. Therefore, the very low relative reactivity of *tert.* butanol indicates that the reaction proceeds by simple hydrogen-atom transfer from the alcohol to the quinone, as in (*a*).

A detailed account of the kinetics and rate constants will be given elsewhere. This work forms

part of the fundamental research programme of the Council of the British Rayon Research Association.

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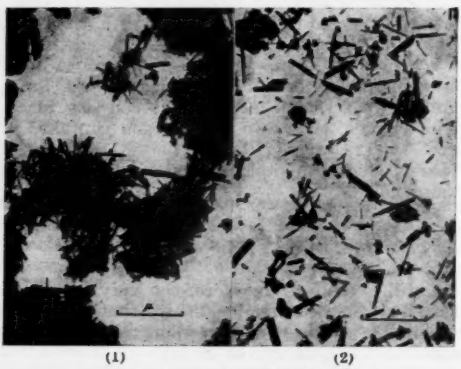
Petroleum Ether (80°-100° C.) used as a Dispersing Agent for the Examination of Particulate Matter by Electron Microscopy and Electron Diffraction

In these laboratories, many powders of electrochemical interest have been produced and their structural properties examined by electron microscopy and electron diffraction, using a Metropolitan-Vickers *E.M.*3 instrument.

Deposits obtained from aqueous suspension methods utilized initially for specimen grid preparation frequently resulted in the aggregation of the fine particles present so that it was found necessary to employ a dispersion technique. Specimens made for transmission electron diffraction have always been degreased by spraying with a fine jet of petroleum ether. It was the use of petroleum ether in this connexion which led to the idea of determining its efficiency as a dispersing agent. For most of the substances which have so far been studied here, satisfactory dispersions of fine particles have been obtained by employing the following simple method.

A small quantity of the powder is placed on to a clean glass microscope slide. From a wash bottle constructed using 'Quickfit' ground-glass joints and having a fine jet, a few drops of petroleum ether are directed on to the powder. This is then crushed to a very fine paste by means of a lancet-pointed dissecting needle.

More dispersing agent is applied and the flat blade of the needle is moved across the slide, thus removing the larger particles and leaving a 'smear' of extremely fine particles. The 'smear' is moistened with a further small quantity of petroleum ether and the collodion film on a copper grid is drawn lightly over the dispersed material on the slide using a pair of forceps. After a few seconds (allowed for evaporation of any remaining liquid), the specimen grid is ready for insertion into the electron microscope.



(1) (2)

Fig. 1. Aqueous suspension deposit
Fig. 2. Petroleum ether dispersion

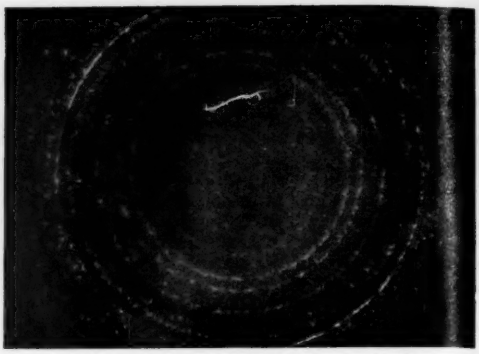


Fig. 3. Electron diffraction pattern from crystals similar to those shown in Fig. 2

The method has the following advantages: (*a*) It is suitable for the majority of inorganic and many organic materials which are insoluble in petroleum ether; (*b*) it is quick, as only one medium is used which rapidly evaporates; (*c*) the dispersed material is deposited on the membrane in such a way that it can be shadowed; (*d*) the dispersion is free from grease and is therefore suitable for electron diffraction.

Synthetic manganese oxides[1], oxides of lead, silver, nickel and vanadium, clay minerals, diatomaceous earth, pyranthrone and flavanthrone are some of the materials which have been investigated in this department by electron microscopy and electron diffraction after successful dispersion using the method described.

Figs. 1 and 2 show the rod-shaped crystals obtained from a sample of α-manganese dioxide (with potassium in the lattice) which had been heated at 400° C. in oxygen for 24 hr. The highly resolved transmission electron diffraction pattern of Fig. 3 was taken from crystals like those in Fig. 2.

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Determination of Arc Temperatures using Shock Waves

Some years ago, Suits[1] suggested and developed a method for the determination of the gas temperature of an arc discharge by the measurement of the velocity of a sound wave passing through the arc channel. The sound wave was obtained from the initiation of a spark discharge, and its propagation was observed by the increased brightness it produced in the channel. In his investigation, Suits observed that the original pressure disturbance created by the spark possessed abnormally high velocities which were rapidly attenuated with the propagation of the disturbance. However, since his experiments showed that for different spark-strengths, and hence for

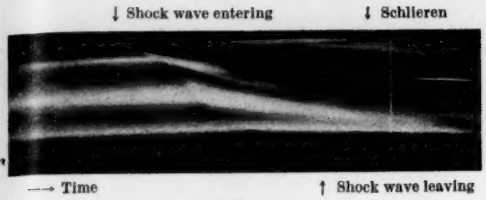

Fig. 1

different abnormal velocities, the same velocity was always obtained when the disturbance had reached the arc, he assumed that the disturbance had become attenuated to one possessing the normal sound velocity.

It is now well known[2] that these abnormal velocities are characteristic of a shock wave which is produced by spark initiation. It would appear, however, that the attenuation allowed by Suits was insufficient to produce a sound wave since (*a*) with a sound wave no arc brightening is to be expected, and (*b*) the records given by Suits show a bodily movement of the arc channel which is most likely due to the mass flow associated with the tail of a shock wave. We suggest, therefore, that Suits observed the passage of a shock wave; and calculations applied to his records indicate that his temperature values are about 5 per cent high due to the application of sound-wave calculation to the relatively weak shocks actually used. The use of strong shock waves would increase the error appreciably. It is also of interest to note that in allowing the shock wave to become attenuated, the sharpness of the pressure front is also reduced, thus producing a brightness change which is difficult to measure accurately. This may explain the relatively few measurable records obtained by Suits.

In the technique which we have developed, the shock wave produced by the spark is not allowed to become attenuated but is, on the contrary, maintained at maximum strength by enclosing the spark in a shock tube. In this way we obtain records showing a large brightness change and which are therefore accurately measurable. It is clear, however, that in these circumstances shock wave theory must be used if large errors are to be avoided. It was found that the application of the Rankine–Hugoniot equations to the arc, considered as a gas of uniform temperature bounded by two simple contact discontinuities, was insufficiently accurate owing to the appreciable radial temperature gradients which exist in the arc. We have therefore developed a theory which gives the variation of velocity of a plane shock wave with a continuously varying temperature distribution. It is then possible to determine the gas temperature at a point *A* if the shock velocity is known at *A* and if the velocity and temperature are known at some other point *B*. In order to obtain these data a schlieren system has been combined with a rotating mirror camera so that the shock propagation can be recorded in the regions outside the arc as well as in the arc channel. The local temperatures outside the arc are easily measured. A typical record is shown in Fig. 1. With this technique we have determined the following arc gas temperatures to an estimated accuracy of ± 150° K., after allowing for shock attenuation. (1) 40-amp. arc in air at 1 atm., cored carbon electrodes with 8-mm. gap, anode above, temperature in middle of gap 6,800° K. (2) 10-amp. arc in nitrogen at 2 atm., tungsten electrodes with 6-mm. gap, cathode above, temperature in middle of gap 6,650° K.

The method is complicated by the shock wave attenuation which occurs in the arc regions; but experiments have now shown that this difficulty may be minimized by using a pulsed arc inside the shock tube. The technique is being further developed in order to determine the decay of gas temperature subsequent upon arc interruption. It will be appreciated that by using a schlieren system the method is applicable to other determinations of non-luminous high gas temperatures.

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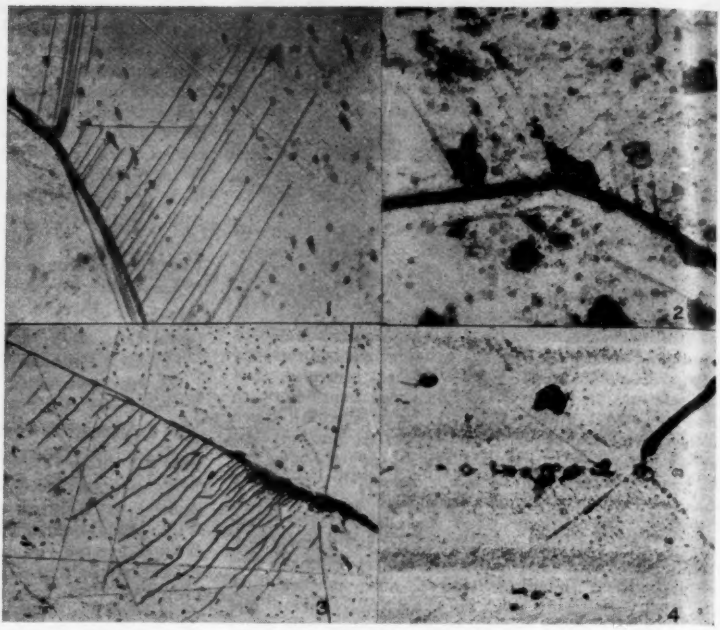
Crystallite Orientation in the Tooth Dentine of *Macropus*

Mammalian dentine consists mainly of hydroxyapatite crystallites with an average size of about 0·03μ [1], and collagen fibres. If the latter are removed from a dentine section and the preparation embedded in a medium with a refractive index high enough to eliminate 'form' birefringence, the optical properties of the mineral are then seen, and it has been shown that the crystallites are orientated in definite patterns[2]. They may lie with their optic axes parallel with the original direction of the collagen fibres, parallel with the dentine tubules, or they may be 'spheritically' orientated.

In longitudinal sections of *Macropus* dentine, crystallites tend to lie parallel with the original collagen direction. However, in the root near the pulp cavity an unusual effect has been noticed, for when viewed between the crossed nicols of a polarizing microscope, such areas show well-defined black lines running across the dentine tubules (Fig. 1). The birefringent crystallites are arranged approximately at right angles to these lines, which are not artefacts produced by the embedding medium and which were initially thought to be zones either containing a different, isotropic mineral, or else possessing a low degree of calcification. It was later found that these lines may still be seen when a section is examined in plane-polarized light, but they are extremely faint and only visible when at right angles to the polarizer; rotating the section causes them to appear and disappear alternately.

Fig. 1. Appearance of extracted *Macropus* dentine between crossed nicols

The explanation of this phenomenon now appears to be that all the mineral in the dentine is the same, but a somewhat regular, double orientation of crystallites exists. The majority of the crystallites lie in the plane of the section and therefore exhibit two refractive indices (n_e and n_o). These are broken up into groups by lines of similar crystallites the optic axes of which are perpendicular to the plane of the section and, therefore, show only one refractive index (n_o) and have no activity between crossed nicols. If the optic axes of the crystallites in the plane of the section are parallel with the vibration direction of the polarizer, the plane-polarized light is subject to the extraordinary refractive index (n_e), and the lines, which are at right angles to this vibration direction, will appear since the index of their mineral is somewhat different (n_o). On rotating the section through 90° all the crystallites will be showing the same index (n_o) and the lines become invisible.



(1) Slip bands near a fatigue crack. × 570. Etch: 15% hydrofluoric acid, 35% hydrochloric acid, 50% water

(2) As Fig. 1 but specimen heat-treated and etched to produce etch pits

(3) Wavy slip bands. × 570

(4) Crystallographic crack and markings in a commercial alloy. × 1,500. Etch: 10% sodium hydroxide

Thanks are due to the Zoological Society of London for the material. It is hoped that a complete account of the structure of marsupial teeth will soon be available.

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Slip during Fatigue of an Age-hardened Alloy

It has long been suspected that the room-temperature fatigue properties of age-hardened aluminium alloys are dependent upon any over-ageing that may occur during a fatigue test[1]. This has recently been directly verified by comparison of fatigue behaviour at room and liquid-air temperatures[2]. It is supposed that alternating stresses cause dislocation movements which in turn generate vacant lattice sites. At room temperature these are mobile and can give rise to over-ageing by reason of the increase in the local diffusion-rate. At liquid-air temperatures this cannot occur, and the fatigue properties are much superior.

However, practically nothing is known about slip processes in age-hardened alloys. No slip bands are seen when single crystals are extended, and the stress–strain curves show little dependence upon orientation[3]. Nevertheless, examination of an aluminium alloy containing 6·6 per cent zinc, 3·0 per cent magnesium and 1·4 per cent copper and aged to peak ultimate tensile stress of 38·2 tons/sq. in., has revealed slip bands in specimens fractured in fatigue at room-temperature. Those shown in Fig. 1 were produced by etching a polished longitudinal section of a specimen which had broken after 10^5 cycles of $\pm$ 19·1 tons/sq. in. The crack is parallel to one set of bands and changes direction at a grain boundary (revealed by a different etch). It proved impossible to develop etch pits for the determination of crystal orientation in the fully hardened alloy; but after over-ageing specimens at 200° C. for a short time, satisfactory pits could be produced. At the same time, however, the bands disappeared and could not be re-etched. This suggests that the original etching effect was due to solute atoms which had segregated to dislocations stuck in the slip band, and that at 200° C. some redistribution occurred. The development by alternating strains of a yield point in this type of alloy has been noted[4] and supports this suggestion.

The structure shown in Fig. 2 was produced by re-etching the surface of the specimen shown in Fig. 1 after over-ageing but without intermediate repolishing. It is apparent that while two sets of traces may possibly be ascribed to intersections of (111) planes with the surface, the third may not. In aluminium, slip on (111) planes is commonly found, but very occasionally slip on (100) and (110) planes occurs in polycrystalline specimens deformed in tension[5]. The third trace is consistent with either (100) or (110) planes. This has been found for numerous bands: in addition wavy slip is also seen, as shown in Fig. 3.

No bands were found in a specimen fatigued at liquid-air temperatures.

The existence of many potential slip bands in age-hardened alloys undergoing fatigue provides an additional explanation of the poor fatigue properties of some age-hardening alloys relative to their static strength properties. Besides the possibility of over-ageing, slip can more readily occur in any one crystal and be transmitted to its neighbours. The alloy described is simply a super-pure version of a common commercial alloy, and it is of interest that crystallographic cracking can be found in such an alloy, although its analysis is complicated by the presence of gross inhomogeneities and intermetallics (Fig. 4).

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Apparent Velocity of Alpha-Particles in Cloud Chambers

Visual demonstration of α-tracks in cloud chambers, especially of the diffusion type, sometimes gives the impression that the tracks actually shoot out from the radioactive source in a fraction of a second (not unlike the smoke trail of a train moving in a distant landscape, though the time-scale is different). It is curious not to find this effect mentioned in the literature, though it must baffle those teachers that have to correct their pupils when they think it is the actual velocity of the particles they are observing.

We suggest the phenomenon is due to the finite diffusion-rate of vapour molecules to the droplets that are forming, their growth being slower at the end of the track because of the stronger competition due to the larger density of ionization. Assuming the known values of this density and assuming the track to be a cylindrical sink in the diffusion field, we find the right order of magnitude for the retardation at the end, the track being fully developed in somewhat less than a second near the end, and in about half that time in the central part.

On a similar basis rests the explanation of a related condensation phenomenon that may be observed with yet simpler means. When one looks at a small light source through a flask with moist air in which an adiabatic expansion is produced (for example, by sucking through a rubber tube) a coloured diffraction halo around the light source is seen. It is, however, not stationary, but at first moves inward during a fraction of a second. This must be attributed to an increase in the size of the fog droplets, due to the same finite diffusion-rate of the water vapour (and of the heat dissipation). Here the sink to be used in the calculation is the spherical droplet itself.

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An Unusually Radioactive Fossil Fish from Thurso, Scotland

During recent investigations on the distribution of radioactive elements in phosphates[1], it was noted that many of the Old Red Sandstone fish remains from north-east Scotland have an abnormally high radioactivity; in particular an unidentified *Homostius* plate (GSM 89090) was shown by rough radiometric assay to have an activity equivalent to 0·5 per cent U_3O_8.

More detailed radiometric assays we have carried out indicated that this material is either in a state of secular disequilibrium, or contains appreciable amounts of thorium. As the latter alternative seemed the more likely, part of the specimen was assayed chemically (Radiochemical Group, Chemical Research Laboratory, Teddington) and found to contain 0·32 per cent U_3O_8 and 0·51 per cent ThO_2, a result which is in excellent agreement with the equivalent U_3O_8 value of 0·48 per cent obtained on the same sample. On obtaining chemical confirmation that appreciable thorium is associated with this particular fish plate, additional investigations were undertaken in an endeavour to obtain more information on the distribution of the radioactive elements within the plate.

In thin section the plate is opaque except where small amounts of interstitial calcite occur; but in polished section the bone structure can be seen clearly (Fig. 1). The bone cavities are filled with hydrocarbon or hydrocarbon partly replaced by calcite. Accessory minerals recognized in the polished sections are pyrite and chalcopyrite.

The mineral constituting the bone tissue was identified by normal optical methods and by X-ray powder photographs of an untreated sample, and of a similar sample ignited to destroy the associated hydrocarbon. Powder photographs of fluorapatite and of carbonate-fluorapatite were also taken for comparison purposes. The X-ray data on which the identification is based are given in Table 1.

It is apparent from the above observations that the apatite of the bone matrix has an a cell dimension between carbonate-fluorapatite and fluorapatite, but a c dimension somewhat greater than the other carbonate-fluorapatites examined. The refractive indices of the ashed material, $\omega = 1{\cdot}628$ and $\varepsilon = 1{\cdot}616$, however, are in good agreement with carbonate-fluorapatite, and since fluorine and only a trace of chlorine were detected chemically (C. O. Harvey, Geological Survey and Museum), it seems reasonably certain that the Thurso material is in fact a carbonate-fluorapatite.

Table 1. Cell Dimensions of Some Varieties of Apatite

	a (in A.)	c (in A.)
1. Hydroxylapatite, Holly Springs, Ga., U.S.A.	9·413	6·875
2. Fluorapatite, Bob Lake, Canada	9·396 ± 0·005	6·879 ± 0·005
3. Fluorapatite, Durango, Mexico	9·386	6·878
4. Apatite from *Homostius* bone tissue, Thurso, Scotland (Untreated)	9·356 ± 0·01	6·910 ± 0·01
(Ashed)	9·366 ± 0·005	6·894 ± 0·005
5. Carbonate-fluorapatite, Staffel, Germany	9·344	6·881
6. Carbonate-fluorapatite, Florida, U.S.A. (Untreated)	9·339 ± 0·005	6·894 ± 0·005
(Ashed)	9·351 ± 0·005	6·885 ± 0·005

Determinations 1, 3 and 5 are by Z. S. Altschuler, E. A. Cisney and I. H. Barlow using an X-ray diffractometer. Abstract in *C.R. XIX Int. Geol. Congr. Algiers*, 11, 9 (1952).
In determinations 2, 4 and 6 a 114·6-mm. diameter camera was used with copper $K\alpha$ radiation and an internal standard of potassium chloride; a was determined from the reflexion $41\bar{5}0$ and c from 0004.

Fig. 1. Polished section of *Homostius* plate showing bone matrix (medium grey), hydrocarbon (light grey) and calcite (dark grey). The white specks are pyrite. × 45

Autoradiographs prepared from polished sections show that whereas both the bone matrix and the hydrocarbon are radioactive (Fig. 2), the alpha-track density of areas corresponding to the hydrocarbon is approximately 1·5 times that of areas corresponding to bone matrix. Measurements of the lengths of alpha-tracks clearly indicate that those of sufficient energy to be attributed to polonium-212 are present only in emulsion that had been in contact with the hydrocarbon, and it is therefore concluded that the thorium is concentrated in the hydrocarbon and does not occur in the bone phosphate. It was further shown from a comparison of the alpha-track population and the U_3O_8 and ThO_2 values obtained chemically that some uranium occurs with the thorium in the hydrocarbon.

Fig. 2. Autoradiograph of same field as Fig. 1 showing concentrations of alpha-tracks corresponding with areas of hydrocarbon. The calcite is inactive. × 45

These observations indicate that whereas both uranium and thorium form organic complexes or compounds with hydrocarbon, only uranium is fixed by bone apatite under the conditions appertaining in this instance. Had the uranium and thorium been taken up under reducing conditions, it would have been expected that thorium (ionic radius 1·02 A.) would have replaced calcium (radius 0·99 A.) in the carbonate-fluorapatite lattice in the same way as the tetravalent uranium ion (radius 0·97 A.) could have done; but since thorium is not present in the bone apatite, it is assumed that uranium is fixed by some other mechanism. The most likely method of fixation would seem to be that suggested by Neuman and his co-workers[2], in which the uranyl ion (UO_2^{++}) combines with two adjacent phosphate groups at the surface of the bone apatite crystals and displaces a calcium ion. This type of exchange adsorption could explain such observed phenomena as the marginal concentration of uranium on apatite crystals, on fossil teeth, and on some phosphorite nodules. It also explains why uranium in ground-water is not substituted for calcium in other common calcium minerals.

We are indebted to Mr. J. E. T. Horne for his assistance in deriving the X-ray data. The communication is published by permission of the Director of the Geological Survey and Museum.

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Differences in Proportion of Fawns to Hinds in Red Deer (*Cervus elaphus*) from Several New Zealand Environments

From more than a hundred liberations, between 1851 and 1923, red deer have spread into the majority of forested areas in New Zealand. In the present communication autumn fawn/hind ratios in New Zealand are compared between five different areas and within each area on two successive years, 1952 and 1953.

The relative proportions of fawns to hinds are shown in Table 1, where hinds are given an arbitrary value of 100. Samples of deer were taken in autumn for comparison with ratios available on deer in the northern hemisphere.

New Zealand fawn/hind ratios show highly significant differences in the five environments tested. Fawn/hind ratios range from $28(\pm 10)/100$, in the Central North Island, to $70(\pm 14)/100$ in the Nelson-Marlborough area, South Island (Table 1). Such differences perhaps could be expected in New Zealand, as red deer range over a wide variety of contrasting environments. Similarly, for adult stags in autumn, differences in fat reserves have recently been demonstrated for several different New Zealand environments[1].

Fawn/hind ratios varied more between different areas than similar ratios taken from the same area

Table 1. FAWN/100 HIND RATIOS FOR RED DEER (*Cervus elaphus*) FROM FIVE NEW ZEALAND AREAS

Area	Total animals	Fawns/ 100 Hinds	Approx. 90 per cent confidence limits
Central North Island	134	28	± 9·8
Nelson–Marlborough	284	70	± 13·9
Canterbury	224	39	± 9·6
Southern Lakes	272	47	± 10·1
South Westland	96	35	± 13·5
All areas	1,010	47	

Corrected χ^2 (ref. 1) to test differences between the areas was 20·62, with a probability of a greater value 0·0004. Approximate 90 per cent confidence limits were calculated using the formula

$$\frac{100F}{H} \pm \left(100\sqrt{\frac{(F+H)F}{H^3}}\right) 1{\cdot}6449.$$

for two consecutive years. Three of the five areas showed no significant difference between fawn/hind ratios taken in 1952 and 1953. Values for the three areas were: Central North Island, 27/100–31/100 ($\chi^2 = 0{\cdot}023$); Nelson–Marlborough, 67/100–75/100 ($\chi^2 = 0{\cdot}228$); and Southern Lakes, 48/100–47/100 ($\chi^2 = 0{\cdot}00015$).

Southern Lakes, South Westland, Canterbury and Central North Island habitats include most of the deer population in New Zealand. Fawn/hind ratios from these four areas combined (41(±4)/100) correspond closely to those recorded by Alex-Hansen[2] from Jutland (38·5/100), near the northern limit of the range of the European red deer, and are significantly less ($\chi^2 = 6{\cdot}84$) than those ratios of 60/100 recorded from Scotland and Germany by Darling[4] and Müller-Using[5] respectively.

Grateful acknowledgment is made to those Government shooters who co-operated in recording results of unselective shooting to make these data available. This work was done while I was employed by the Department of Internal Affairs. The formula for approximate 90 per cent confidence limits was supplied by the Applied Mathematics Laboratory, Department of Scientific and Industrial Research, New Zealand.

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The Reniform Nematode in the Gold Coast

THE reniform nematode (*Rotylenchulus reniformis*) was first described as an obligate parasite on the roots of many plants in Hawaii[1], and a list of sixty-five hosts was given by Linford and Yap[2]. Subsequent records[3–5] have added a further five hosts from the United States.

The occurrence of the reniform nematode has now been noted on a number of hosts at three sites in the Gold Coast, West Africa.

Plants on which this nematode has been found capable of egg production in the Gold Coast are: *Amaranthus spinosus* L.*, *Citrus limon* Burm. f.*, *Crotalaria juncea* L., *Crotalaria striata* D.C., *Daucus carota* L. var. *sativa* D.C., *Glycine max* Merr.*, *Hibiscus esculentus* L., *Ipomoea batatus* L.*, *Lycopersicon esculentum* Mill., *Manihot esculenta* Grantz.*, *Nicotiana tabacum* L., *Persea americana* Mill.*, *Poinciana pulcherrima* L.*, *Solanum melongena* L. var. *esculentum*, *Sorghum vulgare* Pers., *Synedrella nodiflora* Gaertn.*, *Vigna sinensis* Endl., and *Zea mays* L. Those marked with an asterisk are new host records for the reniform nematode.

Life-history studies suggest that the West African forms have a shorter life-cycle than those described by Linford and Oliveira[1]. Soya grown from seed in soil infested with *Rotylenchulus* contained swollen forms after four days, mature females with gelatinous matrix after seven days; egg-laying commenced at ten days, and, fifteen days after sowing, second-generation larvæ were hatching within the egg-masses.

All three sites were old centres of European cultivation within fifteen miles of the capital, Accra, so it is not possible to say whether the reniform nematode is indigenous to the Gold Coast. A more detailed account will be given elsewhere at a later date.

I wish to thank Dr. J. B. Goodey, Nematology Department, Rothamsted, and Dr. S. A. Sher, Division of Plant Nematology, Riverside, California, for help and advice.

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Regulation of Outbreeding in Field Beans (*Vicia faba*)

IT has been reported that field beans show about 30 per cent of cross-fertilization in eastern England[1], and rather more in eastern France and Germany[2]. In the course of some pollination experiments at the Plant Breeding Institute, evidence has been obtained of a natural regulating mechanism which stabilizes this breeding structure.

The plants studied came from commercial seed, inbred lines, and F_1 hybrids, and were grown in an insect-proof glasshouse. Several self- and cross-fertilization treatments were applied, and the results of three of these are set out in Table 1, expressed as the mean number of seeds obtained per flower treated.

It can be seen that, on inbreeding, the ability to set seed without some manipulation of the flower was progressively lost. In most cases it was immaterial whether self- or cross-pollen was applied, except in the more advanced inbreds, where cross-pollen was more effective, possibly indicating some degree of self-incompatibility in this group. On hybridization,

Table 1

Group	Treatment *a*	*b*	*c*
Commercial sample	0·56	2·97	2·89 ± 0·266
Second-generation inbreds	0·27	2·13	1·87 ± 0·158
Fourth-generation inbreds	0·04	1·42	2·14 ± 0·123
F_1 hybrids between third-generation inbreds	1·36	1·98	2·09 ± 0·133

(*a*) *Control*: flowers left untreated. (*b*) *Artificial self-pollination*: keel of mature flower depressed to push self-pollen on to the stigma. (*c*) *Mixed pollination*: as (*b*), but foreign pollen placed on stigma in addition to self-pollen already there.

spontaneous self-fertility was restored; in fact, in this respect the hybrids surpassed the commercial sample.

In the field, flowers may be pollinated by bees (similar to treatment *c*) or pods may be formed from unvisited flowers (as in treatment *a*). The results above suggest that although all types will be equally fertile after bee pollination, those plants arising from cross-fertilization in the previous year will set more seed from unvisited flowers than others in the population. As seed set in the absence of bee visitation must be entirely self-fertilized, this will mean that cross-bred plants will bear a higher proportion of selfed seed than plants derived from one or more generations of self-fertilization.

This unusual breeding behaviour has several important consequences:

(1) The ability of some plants to set seed on unvisited flowers ensures maintenance of the population even in years of low bee activity.

(2) The distribution of this self-set seed mainly on the more heterozygous members of the population restricts the rate of fixation of genetic variability under these conditions.

(3) The undiminished fertility of the inbred plants when pollinated by bees promotes rapid remixing of genetic material under favourable conditions.

The overall effect will be to maintain the population in a stable state of intermediate heterozygosity, in spite of disturbing factors such as seasonal variation in the level of bee activity, and the selective elimination of inbred plants under adverse environmental conditions.

The regulating mechanism described is of interest as it represents a means of maintaining a moderate degree of heterozygosity without complete dependence on insect pollinators.

Jean M. Drayner

Plant Breeding Institute,
Cambridge.
Dec. 9.

[1] Fyfe, J. L., and Bailey, N. T. J., *J. Agric. Sci.*, **41**, 371 (1951). Fyfe, J. L., *J. Agric. Sci.*, **45**, 141 (1954).
[2] Picard, J., *Ann. Inst. Nat. Rech. agron. Paris*, **3**, B, 57 (1953).

Cytogenetics of South American Orthoptera

This is a preliminary report of an investigation in progress dealing with cytogenetics of orthopteran insects of the southern hemisphere belonging to the family Acrididae and new to cytology. In this report the number of chromosomes is established, taking specially into account the existence of metacentric chromosomes. We have studied thirty-two species of four subfamilies, as shown in Table 1.

Table 1

Species	Diploid number $2n$ (♂)	No. of meta-centrics	*X*-chromo-some	No. of chromo-some arms
Subfam. Acridinae				
Dichroatettix bohlsi (Giglio-Tos) Rehn	23	—	free	23
Hyalopteryx rufipennis Charpentier	23	—	free	23
Staurorhectus longicornis G. Tos	23	—	free	23
Scyllinops bruneri (Rehn)	23	—	free	23
Scyllinops pallida (Bruner)	23	—	free	23
Rhammatocerus pictus (Bruner)	23	—	free	23
Amblytropidia australis Bruner	23	—	free	23
Parorphula graminea Bruner	23	—	free	23
Orphulella punctata (De Geer)	23	—	free	23
Dichromorpha australis Bruner	23	—	free	23
Sinipta dalmani (Stal)	23	—	free	23
Laplataeris dispar Rehn	23	—	free	23
Metaleptea brevicornis adspersa (Blanch.)	23	—	free	23
Allotruxalis strigata (Bruner)	23	—	free	23
Subfam. Cyrtacanthacridinae				
Neopedies brunneri (Giglio-Tos) Heb.	23	—	free	23
Scotussa lemniscata (Stal) Lieb.	23	—	free	23
Aleuas brachypterus Bruner	19	4	free	23
Dichroplus punctulatus (Thumb)	23	—	free	23
Dichroplus conspersus Bruner	23	—	free	23
Dichroplus elongatus Giglio-Tos	23	—	free	23
Dichroplus bergi (Stal)	22	1	fused	23
Dichroplus pratensis (Bruner)	18	1	free	19
Dichroplus pratensis ?	18	5	fused	23
Dichroplus sp. (brachypteran form)	8	4	*X–Y*	12
Subfam. Romaleinae				
Xyleus fuscipennis (Bruner) Gistel.	23	—	free	23
Elaeochlora viridicata (Serville) Stal	23	—	free	23
Chromacris speciosa (Thunberg)	23	—	free	23
Zoniopoda tarsata cruentata (Blanch) Rehn	23	—	free	23
Tropinotus laevipes (Stal) Gistel.	22	1	fused	23
Diponthus maculiferus (Walker) Stal	21	2	free	23
Atrachalacris unicolor	22	1	fused	23
Subfam. Ommexechinae				
Ommaexecha servillei Blanchard	21	2	free	23

In *Aleuas brachypterus*, *Diponthus maculiferus*, *Ommaexecha servillei* and *Dichroplus pratensis*, the reduction of chromosome numbers has taken place by centric fusion of two acrocentric (rod-shaped) autosomes, whereas in *Tropinotus laevipes*, *Atrachalacris unicolor*, *Dichroplus bergi* and some forms of *D. pratensis* this evolutionary change took place between autosomes and sex chromosomes, producing in this case an *XY–XX* sex-determining mechanism by formation of a neo-*Y*, neo-*X* system in the male[1].

Particularly interesting is the genus *Dichroplus*, which shows interspecific variation in the number of chromosomes. As Table 1 shows, there is a numerical series ranging from the ancestral karyotype $2n$ (♂) = 23 to the surprising number of $2n$ (♂) = 8. Some forms of *D. pratensis* give 18 diploid chromosomes, while the number of major chromosome arms is not reduced, remaining 23. Other forms of this genus, on the contrary, have also 18, but the number of arms is reduced to 19, which means that four chromosomes have probably been lost.

The rather striking extreme case is the brachypteran form of *Dichroplus* that shows eight diploid elements, meaning that eleven chromosomes had been lost of the original complex. In these individuals the sex chromosome does not behave as an odd element, since it is associated with a small chromosome so as to form a heterozygous acrocentric bivalent, segregating in the first meiotic division as an *X–Y* complex.

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Montevideo, Uruguay.
Nov. 1.

[1] White, M. J. D., "Advan. Genet.", **4**, 267 (1951); "Animal Cytology and Evolution" (Camb. Univ. Press, 1954).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 12

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. J. M. Zarek: "Behaviour of Materials in the Human Body".*

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Reynolds Hall, College of Technology, Manchester), at 5.45 p.m.—Dr. W. Idris Jones: "Britain's Fuel and Power Prospects". (Clayton Memorial Lecture.)

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Mining Institute, Newcastle-upon-Tyne), at 6.15 p.m.—Dr. J. F. Allan: "Effect of Roughness in Ship Resistance".

Tuesday, March 13

UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL (at University Street, London, W.C.1), at 4.30 p.m.—Prof. C. Rimington, F.R.S.: "The Biosynthesis of Hæmoglobin" (Sydney Ringer Memorial Lecture).

PHYSICAL SOCIETY (in the Lecture Theatre, The Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Sir Francis Simon, F.R.S.: "The Third Law of Thermodynamics—an Historical Survey". (40th (1956) Guthrie Lecture.)*

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

IMPERIAL COLLEGE (in the Main Chemistry Lecture Theatre, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Prof. Arthur Porter: "The Control of Processes". (Inaugural Lecture.)

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. A. de Dani: "The Use of Reinforced Plastics in the Chemical Industry and Some Chemical Problems Connected Therewith".

Wednesday, March 14

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. Michael Wyatt: "The Monadhliath Adamellite, Inverness-shire" (to be read by Dr. S. O. Agrell); Mr. Scott Simpson: "On the Trace-fossil *Chondrites*".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Dr. C. L. Mallows: "Generalizations of Tchebycheff's Inequalities".

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. J. A. Shaw: "Refinery Utility Installations".

MALACOLOGICAL SOCIETY OF LONDON (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Meeting on "Pelagic Mollusca—Swimmers and Drifters".

SOCIETY OF CHEMICAL INDUSTRY, FOOD AND MICROBIOLOGY GROUPS (at the Chemical Society, Burlington House, Piccadilly, London, W.1) at 6.30 p.m.—Dr. M. Ingram, Mr. F. J. H. Ottaway and Dr. J. B. M. Coppock: "The Preservative Action of Acidic Substances in Foods".

Thursday, March 15

PHYSICAL SOCIETY, OPTICAL GROUP (at Imperial College, London, S.W.7), at 2.30 p.m.—Annual General Meeting, followed by Scientific Papers.

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (at the Royal School of Mines, London, S.W.7), at 4 p.m.—Dr. E. H. Putley and Mr. Vernon Roberts: "The Properties of Semiconductors at Low Temperatures".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Meeting for Election of Fellows. 4.30 p.m.—Mr. R. G. West: "The Quaternary Deposits at Hoxne, Suffolk"; Mr. G. M. Brown: "The Layered Ultrabasic Rocks of Rhum, Inner Hebrides".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. W. H. Wilson: "An Account of the Exploration of the Avoca Mines, County Wicklow, Ireland"; Mr. D. G. Armstrong: "The Design, Construction and Operation of a Laboratory Classifier".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. K. Kuratowski: "On the Topology of Continuous Complex-Valued Functions".

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. C. D. J. Statham: "Underground Lighting in Coal Mines".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, W.1), at 6 p.m.—Mr. D. G. Ainley: "The High Temperature Turbo-Jet Engine".

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (in the Lecture Hall, Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1), at 6 p.m.—Mr. A. H. Thornelœ: "The Assessment of the Properties of Mortar and Plastering Mixes"; Dr. J. W. Skeen: "Mortar Plasticisers".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at the Royal Army Medical College, Millbank, London, S.W.1), at 7.30 p.m.—Laboratory Meeting. Chairman: Prof. R. M. Gordon, Q.B.E.

Friday, March 16

SOCIETY FOR WATER TREATMENT AND EXAMINATION (at Caxton Hall, Caxton Street, London, S.W.1), at 9.30 a.m.—Annual General Meeting and Scientific Papers.

BRITISH ASSOCIATION OF CHEMISTS (in the Barnes Hall, Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 6 p.m.—Mr. T. McLachlan: "The Analyst—Chemist, Technician or Magician?"

INSTITUTION OF MECHANICAL ENGINEERS, INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "The Development of Automatic Control in Industry".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Annual General Meeting. 7.30 p.m.—Dr. J. D. Johnson: "Continuous Counter-Current Distribution of Batches of Material".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. W. Grey Walter: "The Imitation of Mentality".

Saturday, March 17

BRITISH MYCOLOGICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 10.30 a.m.—Meeting on "Yeasts".

BRITISH PSYCHOLOGICAL SOCIETY (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. L. Weiskrantz: "Some Effects of Temporal Lobe Lesions on Behaviour in Monkeys".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT (preferably with a degree in one of the natural sciences) IN CHARGE OF THE NATURAL SCIENCES LIBRARY—The Registrar, University College, Singleton Park, Swansea (March 17).

SENIOR SCIENTIFIC OFFICER (with a degree of high standard, with chemistry as a major subject, and several years research experience, and preferably with a knowledge of paint technology) IN THE DEFENCE STANDARDS LABORATORIES, Department of Supply, Maribyrnong, Victoria, Australia, for research and developmental work in connexion with paints, such as the study of methods of measuring the properties of paint films and changes in properties during ageing and weathering, the study of the protection of metals by primers, underwater protection of ships and anti-fouling paints—The Senior Representative (AP.45), Department of Supply, Australia House, Strand, London, W.C.2 (March 19).

FORESTRY ASSISTANT (with a recognized degree or certificate in forestry) for duties which will include the preparation of Tree Preservation Orders and planting schemes, management of woodlands, consideration of felling licence applications and general liaison with the Forestry Commission—The Planning Officer, Peak Park Planning Board, Aldern House, Bakewell, Derbyshire (March 21).

RESEARCH WORKER (with an honours degree in biochemistry or equivalent qualification) IN THE DEPARTMENT OF BIOLOGICAL CHEMISTRY, to assist in work on the metabolism of the autotrophic nitrifying bacteria—Prof. W. O. Kermack, Department of Biological Chemistry, Marischal College, Aberdeen (March 24).

SCIENTIFIC OFFICER (with a good honours degree in science) IN THE CEREALS SECTION, to engage in genetical, physiological and breeding research, and an ASSISTANT EXPERIMENTAL OFFICER (with a degree in agriculture or horticulture) for duties as GLASSHOUSE AND PLOT MANAGER—The Secretary, Plant Breeding Institute, Trumpington, Cambridge (March 26).

LECTURER IN THE DEPARTMENT OF FLUID MECHANICS—The Registrar, The University, Liverpool (March 29).

LECTURER (with an honours degree and practical experience in public works engineering) IN CIVIL ENGINEERING—The Registrar, The University, Leeds 2 (March 31).

LECTURER OR ASSISTANT LECTURER IN AGRICULTURAL ZOOLOGY, and a LECTURER OR ASSISTANT LECTURER IN CROP HUSBANDRY at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 2).

SENIOR LECTURER (with a good academic qualification, and wide teaching and/or research experience in tropical agriculture) IN TROPICAL AGRICULTURE at Kumasi College of Technology—The Appointments Secretary, Advisory Committee on Colonial Colleges of Arts, Science and Technology, 1 Woburn Square, London, W.C.1 (April 7).

CHAIR OF MEDICINE at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 19).

CHAIR OF PHYSICAL CHEMISTRY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 20).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN CHEMISTRY, PHYSICS and allied subjects, for example, pharmacology, engineering and metallurgy—The Registrar, The University, Manchester 13 (April 30).

KEEPER OF THE DEPARTMENT OF ARCHÆOLOGY—The Director, National Museum of Wales, Cardiff (April 30).

LECTURER (entomologist, preferably with research interest in insect pests of stored products in the tropics) IN ZOOLOGY at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 30).

PROFESSOR OF MECHANICAL ENGINEERING at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, April 30).

SENIOR LECTURER IN INORGANIC CHEMISTRY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

LECTURER (with practical experience of forestry in Great Britain) IN THE DEPARTMENT OF FORESTRY—The Secretary, The University, Edinburgh (May 31).

PROFESSOR OF AGRICULTURE, and a PROFESSOR OF BOTANY, at the Imperial College of Tropical Agriculture, Trinidad, British West Indies—The Secretary, The Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (June 1).

AERODYNAMICISTS and MATHEMATICIANS (with a first- or second-class honours degree or equivalent, and preferaby with some research or development experience) with the Ministry of Supply at various Experimental Establishments and London Headquarters, for research and development work on aircraft projects, performance analysis of aircraft and weapons, statistics and operational research, guided weapons, gas turbines—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.69/6A/AA.

DEMONSTRATOR IN CHEMISTRY (inorganic, organic and physical)—The Secretary of University Court, The University, Glasgow.

ENGINEERS and PHYSICISTS (particularly with electronics), Senior Scientific and Scientific Officer grades (with a first- or second-class honours degree or equivalent high professional attainments) at Royal Naval Scientific Service Experimental Establishments chiefly in the Weymouth and Portsmouth areas, and the Home Counties—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.344/5A.

LECTURER IN PHYSICAL TESTING OF RUBBER-LIKE POLYMERS, and a SENIOR LECTURER IN PLASTICS TECHNOLOGY—National College of Rubber Technology, Northern Polytechnic, Holloway, London, N.7.

MASTER to teach MATHEMATICS up to university scholarship standard—The Headmaster, Trent College, Long Eaton, Nottingham.

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics or electrical engineering, and considerable experience of servo systems and other electrical mechanical devices) at the Royal Aircraft Establishment, Farnborough, to lead a section engaged in research and development of automatic flight controls—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.76/6A/AA.

RESEARCH ASSISTANT (with a special interest in plant physiology) IN BOTANY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1.

SCIENTIFIC OFFICER (Chemist), ASSISTANT EXPERIMENTAL OFFICER (Chemist), and an ASSISTANT (Scientific), IN THE METROPOLITAN POLICE LABORATORY—The Secretary, Room 165, New Scotland Yard, London, S.W.1.

TECHNICIAN (preferably with some experience in geology) for research in micropalæontology—The Secretary, University College, Gower Street, London, W.C.1, quoting 'Geology/B.P.'.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

British Broadcasting Corporation: Engineering Division. Monograph No. 4: The Design of a Ribbon Type Pressure-Gradient Microphone for Broadcast Transmission. By D. E. L. Shorter and H. D. Harwood. Pp. 22. (London: British Broadcasting Corporation, 1955.) 5*s*. [21

Bulletin of the British Museum (Natural History). Botany. Vol. 1, No. 8: The Heterophyllous *Selaginellae* of Continental North America. By A. H. G. Alston. Pp. 219–274+plates 5 and 6. (London: British Museum (Natural History), 1955.) 16*s*. [21

General Register Office. Census 1951—England and Wales. Index of Place Names. Vol. 1: A–K. Pp. iv+1–654. Vol. 2: L–Z. Pp. 655–1377. (London: H.M. Stationery Office, 1955.) 63*s*. net the two volumes. [21

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 663, Vol. 239 (22 December 1955): The Decomposition of Some Organophosphorus Insecticides and Related Compounds in Plants. By D. F. Heath, D. W. J. Lane and P. O. Park. Pp. 191–214. 7*s*. 6*d*. No. 664, Vol. 239 (22 December 1955): The Ammonite Succession in the Lower Oxford Clay and Kellaways Beds at Kidlington, Oxfordshire, and the Zones of the Callovian Stage. By J. H. Callomon. Pp. 215–264+plates 2 and 3. 19*s*. (London: Royal Society, 1955.) [21

Discovery Reports. Vol. 28, Pp. 1–190: Mysidacea. By Dr. Olive S. Tattersall. (Cambridge: At the University Press, 1955. Issued by the National Institute of Oceanography.) 65*s*. net. [21

National Parks and Access to the Countryside Act, 1949. Sixth Report of the National Parks Commission for the year ending 30th September, 1955. Pp. iv+60+8 plates. (London: H.M. Stationery Office, 1955.) 4*s*. net. [41

The Nature Conservancy. Report of the Nature Conservancy for the year ended 30th September 1955. Pp. iv+56+12 plates. (London: H.M. Stationery Office, 1955.) 4*s*. net. [41

Home Office: Scottish Home Department. Manual of Civil Defence. Vol. 1, Pamphlet No. 1: Nuclear Weapons. Pp. iv+55 (24 plates). (London: H.M. Stationery Office, 1956.) 2*s*. 6*d*. net. [161

N. A. Bulganin and N. S. Khrushchov—Full Texts of Speeches and Statements in India, Burma and Afghanistan. Pp. 47. (London: Soviet Ness, 1955.) [181

London School of Hygiene and Tropical Medicine, incorporating the Ross Institute (University of London). Report of the 30th meeting of the Ross Institute Industrial Advisory Committee, 17th November, 1955. Pp. 28. (London: Ross Institute Industrial Advisory Committee, 1955.) [181

National Union of Teachers. The School Meals Service. Pp. 36. (London: National Union of Teachers, 1955.) [181

Building Research Station Digest No. 83: Index to Building Research Station Digests Nos. 1 to 82. Pp. 6. (London: H.M. Stationery Office, 1955.) 3*d*. [181

Linen Industry Research Association. Report of the Council, 1955. Pp. 20. (Lambeg, Belfast: Linen Industry Research Association, 1955.) [181

West African Cocoa Research Institute. Technical Bulletin No. 3: The Propagation of Cacao by Cuttings. By J. F. Archibald. Pp. 6+6 plates. (London: Crown Agents for Oversea Governments and Administrations, 1955.) 1*s*. 6*d*. [181

University of Cambridge School of Agriculture Memoirs. Memoir No. 27: A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organizations during the period Oct. 1st, 1954–Sept. 30th, 1955. Review Series No. 10: Crop Husbandry Experiments in Cambridge. By F. Hanley. Pp. 30. (Cambridge: School of Agriculture, 1956.) 3*s*. [181

British Hat and Allied Feltmakers Research Association. Eighth Annual Report of the Director of Research for year ending August, 1955. Pp. 23. (Manchester: British Hat and Allied Feltmakers Research Association, 1955.) [181

Other Countries

Report of the King Institute of Preventive Medicine, Guindy, for the period from 1st April 1952 to 31st March 1953. By Dr. Y. S. Narayana Rao. Report of the Government Analyst, Madras. By Sri S. Narayana Ayyar. Pp. 142+2. (Madras: Government Press, 1955.) [161

American Association for the Advancement of Science and participating affiliated and associated societies. General Program—Directory, Atlanta Meeting, December 26–31, 1955 (122nd meeting of the Association). Pp. 352. (Washington, D.C.: American Association for the Advancement of Science, 1955.) [161

Annalen van de Sterrewacht te Leiden. Deel 20, Zestiende Stuk, Uitgegeven door de Directeur der Sterrewacht, Prof. Dr. J. H. Oort. Thirty New Short-Period Variable Stars in a Region Around CPD–31° 5547. By J. Ponsen. Discussion of Fifty Long-Period Variable Stars in a Region Around CPD–31° 5547. By J. Ponsen. Pp. 383–418. (Leiden: Staatsdrukkerij- en Uitgeverijbedrijf, 1955.) [161

Bulletin of the Astronomical Institutes of the Netherlands. Vol. 12, No. 461 (December 3, 1955): 400 Mc./s Partial Eclipse Observations on 30 June 1954. By C. L. Seeger. Pp. 273–284. (Communication from the Netherlands Foundation for Radio Astronomy and the Observatory at Leiden.) (Leiden: The Observatory, 1955.) [161

Proceedings of the American Academy of Arts and Sciences. Vol. 83, No. 6: Thermodynamic Relations in *n*-Variable Systems in Jacobian Form. Part 2: Polyphase Polycomponent Chemical Systems. By F. H. Crawford. Pp. 191–222. (Cambridge, Mass.: American Academy of Arts and Sciences, 1955.) [161

Segundo Catalogo General de Colecciones Micologicas Latino Americanas. Pp. 111. (Montevideo: Centro de Co-operación Cientifica de la Unesco para América Latina, 1955.) [161

Food and Agriculture Organization of the United Nations. Problems of Food and Agricultural Expansion in the Far East. Pp. viii+78. (Rome: Food and Agriculture Organization of the United Nations: London: H.M. Stationery Office, 1955.) 3*s*. 9*d*. [181

Annuaire pour l'An 1956, publié par le Bureau des Longitudes, avec un Supplement pour l'An 1957. Pp. viii+729. (Paris: Gauthier-Villars, 1956.) [181

British Caribbean Meteorological Service. Annual Report, 1954. Pp. 11. (Trinidad: British Caribbean Meteorological Service, 1955.) [181

Council of Scientific and Industrial Research, New Delhi. Rain-Making: Its Present Position and Future Possibilities. By A. K. Roy. Pp. iii+31. (New Delhi: Council of Scientific and Industrial Research, 1955.) [181

Proceedings of the United States National Museum. Vol. 103, No. 3335: On the Anatomy and Relationships of Glossy Cuckoos of the Genera Chrysococcyx, Lampromorpha, and Chalcites. By Andrew J. Berger. Pp. 585–597. Vol. 104, No. 3347: Fishes of the Family Percophididae from the Coasts of Eastern United States and the West Indies, with Descriptions of Four New Species. By Isaac Ginsburg. Pp. 623–639. Vol. 105, No. 3351: An Anatomical Study of the Peregrine Megascolecid Earthworm *Pheretima Hupeiensis* in the Eastern United States. By William C. Grant, Jr. Pp. 49–63. Vol. 105, No. 3356: Populations of the Berycoid Fish Family Polymixiidae. By Ernest A. Lechner. Pp. 189–206. (Washington, D.C.: Smithsonian Institution, U.S. National Museum, 1955.) [181

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